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AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION
OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

Vol. XXXVII April-June 1990

CONTENTS

Contribution to the study of the myxomycetes in Spain. II.
Gabriel Moreno, Carlos Illana, and Michel Heykoop 1
A study of hyphal morphology in the form genus *Rhizoctonia*.
Torben F. Andersen 25
A new species of *Melanomphalia* (Crepidotaceae).
Rolf Singer, Clark L. Ovrebo, and David P. Lewis 47
Columnocystis, a synonym of *Veluticeps*.
Kurt Hjortstam and M.ª Teresa Tellería 53
A new taxon in the genus *Cordyceps* from China.
Mu Zang, Da-rong Yang, and Chao-da Li 57
Interfertility studies on three species of Corticiaceae .... **A. B. De** 63
Acremonium uncinatum, a new endophyte in *Festuca pratensis*.
W. Gams, O. Petrini, and D. Schmidt 67
A new species of *Acaulospora* associated with cocoa in Java and Bali (Indonesia) .... **K. Kramadibrata and J. N. Hedger** 73
Alternaria themes and variations (27—53) .... **Emory G. Simmons** 79
Fusarium morphology I: Identification and characterisation of a third conidial type, the mesoconidium .... **I. G. Pascoe** 121
Fusarium morphology II: Experiments on growing conditions and dispersal of mesoconidia .... **I. G. Pascoe** 161
New species and combinations in *Vermiculariopsiella* (Hyphomycetes).
A. Nawawi and A. J. Kuthubutheen 173
A new species of *Albatrellus* (Aphyllophorales: Albatrellaceae) from Mexico .... **Joseph E. Laferrière and Robert L. Gilbertson** 183
Calvatia pachyderma (Peck) Morgan is *Gastropila fragilis* (Lév.) Homrich & Wright .... **Jorge E. Wright** 187
Escovopsis, a new genus from leaf cutting ant nests to replace *Phialocladus* nomen invalidum.
J. J. Muchovej and Terezinha M. C. Della Lucia 191
Observations on poorly known mangrove fungi and a nomenclatural correction .... **E. B. Gareth Jones and K. D. Hyde** 197

[CONTENTS continued overleaf]

ISSN 0093-4666 MYXNAE 37 1-532 (1990)

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and availability of articles as tear sheets, see inside back cover.

[CONTENTS continued from front cover]

Studies in *Leptosphaeria*. Transfer of *L. massarioides* to *Massariosphaeria*. **S. M. Huhndorf, J. L. Crane, and C. A. Shearer** 203
An emended description of *Furia crustosa* (Entomophthorales: Entomophthoraceae) .... **D. Tyrrell and I. S. Ben-Ze'ev** 211
Meliolaceous fungi from the State of Kerala, India II. The genus *Meliola*. **V. B. Hosagoudar and R. D. Goos** 217
A new pyrenomycete record for the New World .... **Demaris E. Lusk** 273
Morphology and ontogeny of conidia in *Wilsonomyces carpophilus*, gen. nov. and comb. nov., causal pathogen of shot hole disease of *Prunus* species .... **J. E. Adaskaveg, J. M. Ogawa, and E. E. Butler** 275
Exophiala jeanselmei var. *castellanii*, a new combination for *Exophiala castellanii* .... **Tokio Iwatsu and Shun-ichi Udagawa** 291
Albino spores associated with dark-spored species of *Scutellispora*. **Rogério T. Almeida and N. C. Schenck** 293
New or interesting lichenicolous fungi 1. Species from Luxembourg. **Paul Diederich** 297
A new species of *Polyporus* (Aphyllophorales: Polyporaceae) from Mexico. **Joseph E. Laferrière and Robert L. Gilbertson** 331
New and interesting species of *Cladonia* from California. **Samuel Hammer and Teuvo Ahti** 335
Lindtneria panphyliensis sp. nov. from Po Valley, Italy. **Michael J. Larsen and Anarosa Bernicchia** 349
Reexamination of the nomenclatural types of *Polyporus rimosus* Berk. and *P. badius* Berk. .... **Michael J. Larsen** 353
Myxomycetes of Alberta .... **K. A. Richardson and R. S. Currah** 363
Acerviclypeatus, a new genus for the anamorph of *Ophiodothella vaccinii*. **Richard T. Hanlin** 379
Taxonomic and nomenclatural notes on *Laccaria* B. & Br. III. *Laccaria amethystina* and *L. impolita*. **Gregory M. Mueller and Else C. Vellinga** 385
Addition to *Subulispora* from Malaysia. **A. Nawawi and A. J. Kuthubutheen** 389
Obeliospora, a new genus of setose, phialosporous hyphomycetes with appendaged conidia .... **A. Nawawi and A. J. Kuthubutheen** 395
On the correct names for some species of *Melanelia*. **Theodore L. Esslinger** 401
Meliolaceae of South India — VII .... **V. B. Hosagoudar and R. D. Goos** 403
New Australasian species and records in the genus *Leptogium* S. Gray (lichenized Ascomycotina: Collemataceae) .... **Douglas Verdon** 413
Distributional and ecological notes on *Hypocenomyce scalaris* (Lecanorales, Lecideaceae) in eastern North America .... **Robert Dirig** 441
A taxonomic revision of the genus *Cheilymenia* — 2. *Cheilymenia asteropila* spec. nov. and *Cheilymenia gemella* comb. nov. ..... **Jiří Moravec** 463
Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): a new order, Glomales, two new suborders, Glomineae and Gigasporineae, and two new families, Acaulosporaceae and Gigasporaceae, with an emendation of Glomaceae ... **Joseph B. Morton and Gerald L. Benny** 471
Species and clones of arbuscular mycorrhizal fungi (Glomales, Zygomycetes): their role in macro- and microevolutionary processes. **Joseph B. Morton** 493

[CONTENTS continued on back cover]

MYCOTAXON

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TABLE OF CONTENTS, VOLUME THIRTY-SEVEN

April-June, 1990

Contribution to the study of the myxomycetes in Spain. II.
Gabriel Moreno, Carlos Illana, and Michel Heykoop 1

A study of hyphal morphology in the form genus *Rhizoctonia*.
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Acremonium uncinatum, a new endophyte in *Festuca pratensis*.
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Alternaria themes and variations (27—53) .... **Emory G. Simmons** 79

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Fusarium morphology II: Experiments on growing conditions and dispersal of mesoconidia .... **I. G. Pascoe** 161

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A. Nawawi and A. J. Kuthubutheen 173

A new species of *Albatrellus* (Aphyllophorales: Albatrellaceae) from Mexico .... **Joseph E. Laferrière and Robert L. Gilbertson** 183

Calvatia pachyderma (Peck) Morgan is *Gastropila fragilis* (Lév.) Homrich & Wright .... **Jorge E. Wright** 187

Escovopsis, a new genus from leaf cutting ant nests to replace *Phialocladus* nomen invalidum.
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Exophiala jeanselmei var. *castellanii*, a new combination for *Exophiala castellanii* .... **Tokio Iwatsu and Shun-ichi Udagawa** 291

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Reexamination of the nomenclatural types of *Polyporus rimosus* Berk. and *P. badius* Berk. .... **Michael J. Larsen** 353
Myxomycetes of Alberta .... **K. A. Richardson and R. S. Currah** 363
Acerviclypeatus, a new genus for the anamorph of *Ophiodothella vaccinii*. **Richard T. Hanlin** 379
Taxonomic and nomenclatural notes on *Laccaria* B. & Br. III. *Laccaria amethystina* and *L. impolita*. **Gregory M. Mueller and Else C. Vellinga** 385
Addition to *Subulispora* from Malaysia. **A. Nawawi and A. J. Kuthubutheen** 389
Obeliospora, a new genus of setose, phialosporous hyphomycetes with appendaged conidia .... **A. Nawawi and A. J. Kuthubutheen** 395
On the correct names for some species of *Melanelia*. **Theodore L. Esslinger** 401
Meliolaceae of South India — VII .... **V. B. Hosagoudar and R. D. Goos** 403
New Australasian species and records in the genus *Leptogium* S. Gray (lichenized Ascomycotina: Collemataceae) .... **Douglas Verdon** 413
Distributional and ecological notes on *Hypocenomyce scalaris* (Lecanorales, Lecideaceae) in eastern North America .... **Robert Dirig** 441
A taxonomic revision of the genus *Cheilymenia* — 2. *Cheilymenia asteropila* spec. nov. and *Cheilymenia gemella* comb. nov. ..... **Jiří Moravec** 463
Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): a new order, Glomales, two new suborders, Glomineae and Gigasporineae, and two new families, Acaulosporaceae and Gigasporaceae, with an emendation of Glomaceae ... **Joseph B. Morton and Gerald L. Benny** 471
Species and clones of arbuscular mycorrhizal fungi (Glomales, Zygomycetes): their role in macro- and microevolutionary processes. **Joseph B. Morton** 493
NOTICE: MYCOTAXON delivery to foreign countries and consequent changes in prices 517
NOTICE: TAXACOM-NET information service 518

Author INDEX 519
Reviewers 521
INDEX to Fungous and Lichen Taxa 522
Errata 532
Publication Date, MYCOTAXON Volume 36(2) 532

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Vol. XXXVII, pp. 1-24 April-June 1990

CONTRIBUTION TO THE STUDY OF THE *MYXOMYCETES* IN SPAIN. II.*

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ABSTRACT

69 species of *Myxomycetes* are reported from several localities of peninsular Spain. The following taxa are new to Spain: *Diderma platycarpum* Nann.-Brem., *Physarum bogoriense* Racib., *Stemonitis splendens* var. *webberi* (Rex) Lister and *Trichia flavicoma* (Lister) Ing. One species, *Diderma fragilis* Arambarri is new to Europe. All these taxa are figured with microphotographs of their most important taxonomical features.

INTRODUCTION

With this paper we continue our series of contributions (MORENO & al., 1987; 1989; HEYKOOP & al., 1988) of chorological and taxonomical studies of *Myxomycetes* in peninsular and insular Spain.

We have taken as primary object the study of the Natural Park of Monfragüe, located in the province of Cáceres, which extends over an area of 17.850 hectares. Its biological interest is enormous, being one of the most significant european refuges of the mediterranean flora and fauna. It is known principally for its ornithological richness, since there live colonies of birds of prey which are in danger of becoming extinct. At the moment we are realizing a mycological study on some taxonomical groups of this zone. In this paper we contribute the results obtained on the class *Myxomycetes* principally from this park but also from some other localities in Spain.

The complete protologues are indicated and a brief macro- and microscopic description of those species which are new to the spanish mycological catalogue or have been cited only a few times is given. The collector (leg.) is named when the material has been found by others than the authors of this paper.

The material examined is kept in the herbarium of the Department of Plant Biology (Botany) of the University of Alcalá de Henares (H.AH)

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* This Paper was presented at the "Tenth Congress of European mycologists" celebrated in URSS the 20th to 25th August 1989, and at the "VIII Simposios de Ciencias Criptogámicas" celebrated in Melilla (Spain) the 23th to 26th September 1989.

CATALOGUE OF SPECIES LISTED ALPHABETICALLY

Arcyria affinis Rostaf. *emmend.* Nann.-Brem.

This reddish-brown species of Arcyria is close to *A. incarnata* (Pers.) Pers. ROBBRECHT (1973, 1974) distinguishes them by the "crateriform" ornamentation which is present in the calyculus of *A. affinis* (visible under the scanning electronic microscope, SEM) but not in *A. incarnata*; vide microphotographs of CHECA & al. (1982) y LADO (1984).

CACERES: On bark of *Quercus suber*, road from La Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 21-IV-1988, H.AH 10866.

Arcyria cinerea (Bull.) Pers.

This species is widely distributed and it is characterized by its warted capillitium, rarely annulated, with a smooth or slightly reticulated calyculus. It is close to *A. pomiformis* (Leers) Rostaf., and also, macroscopically, to *A. nigella* Emoto, which is cream-coloured; it differs from it both in the internal ornamentation of the calyculus and in that of the capillitium (KELLER & al., 1986).

CACERES: On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 26-XI-1988, H.AH 11386, 11435, 11463 and 11470.

Arcyria denudata (L.) Wettst.

CACERES: On trunk of *Quercus suber* and soil, road from La Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 12-III-1987, H.AH 10499, 10500, 10501, 10502 and 10503.

Arcyria ferruginea Sauter

CACERES: On bark of *Pinus pinaster*, Berzocana, leg.: Fernando Durán, 23-XII-1987, H.AH 10874.

Arcyria incarnata (Pers.) Pers.

CACERES: On woody rests of *Quercus suber*, estate "Las Cansinas" (Natural Park of Monfragüe), 5-XI-1987, H.AH 10504. On bark, wood and dead branch of *Quercus ilex* ssp. *rotundifolia*, Saltaencampo, 9-IV-87, H.AH 10505. On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11433 and 11464. On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11410.

CUENCA: On wood of *Pinus pinaster*, Uña, 27-X-1988, H.AH 11380 and 11403.

MADRID: On wood of *Pinus pinaster*, Cuesta Zulema, Alcalá de Henares, 26-I-1989, H.AH 11566.

Arcyria obvelata (Oeder) Onsberg.
= Arcyria nutans (Bull.) Grev.

BADAJOZ: On wood of broad-leaved tree, Argallón stream, Azuaga, 22-X-1988, leg.: J.R. García, H.AH 11448.

CACERES: On piled trunks of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 9-V-1987, H.AH 10506. Idem, 21-IV-1988, H.AH 10875 and 10876. On dead branch of *Quercus suber*, estate "Las Cansinas", (Natural Park of Monfragüe), 22-XI-1985, H.AH 9541. On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11432. On wood of *Pinus pinaster*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11456.

MADRID: On a trunk of *Betula pendula* ssp. *fontqueri*, mountain pass of Somosierra, 6-IX-1988, H.AH 11469.

Arcyria pomiformis (Leers) Rostaf.

Characterized by its persistent strongly ornamented capillitium wich is united to the cup of the sporocyst, and its pale-yellow colour. It can be confused with *A. pausiaca* Keller & Buben-Zurey, a species described recently, which can live on the bark of living trees; the latter is olivaceous-green and presents a capillitium which (is not elastic and) doesn't expand at the maturity (KELLER & al., 1986). It is also close to *A. nigella* Emoto, which presents cylindrical gregarious cream-coloured or grey sporocysts and a capillitium which is banded reticulate and does not expand (KELLER & al., op. cit.).

CACERES: On rotten wood of *Quercus suber*, estate "Las Cansinas" (Natural Park of Monfragüe), 5-XI-1987, H.AH 10507. On a trunk of a living *Phoenix canariensis with Epithele canariensis*, Miajadas, 2-XI-1987, H.AH 10508, 10509 and 10510. On wood of *Quercus suber*, with *Pulcherricium caeruleum*, estate "Las Cansinas" (Natural Park of Monfragüe), 12-XI-1985, H.AH 10883. On wood of *Eucalyptus camaldulensis*, mountain pass of los Castaños, 26-XI-1988, H.AH 11471. On wood of a broad-leaved tree, Valle del Jerté, Los Pilones, 22-IX-1988, H.AH 11472.

Badhamia dearnessii Hagelst., Mycologia 34: 117. (1942). (Figs. 1-5)

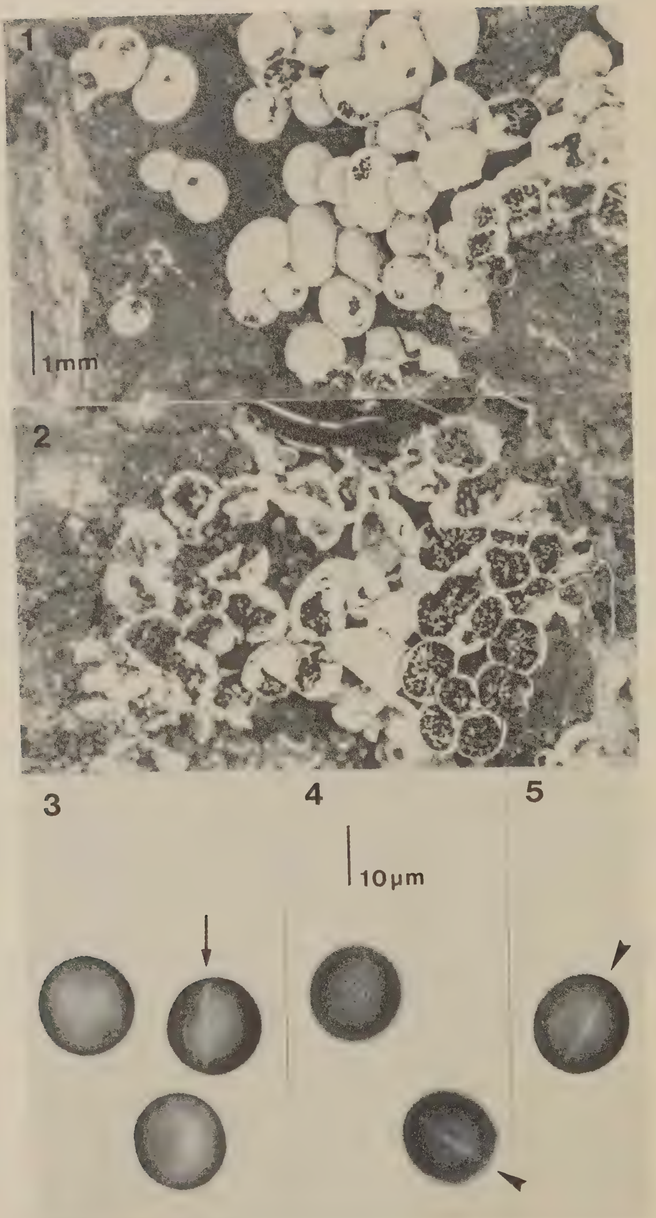
Fructifications sporangiate. Sporocysts gregarious or in small groups, subglobose, sessile or with short stalks of 1-1,5 mm in heigth. Peridium ash-grey, with white veins due to the capillitium showing through. Dehiscence irregular. Capillitium formed by delicate filaments radiating from the centre and which ramify to the peridium with few anastomoses. Spores black in mass, brown-violaceous under the microscope, free, globose, densely warted, with incomplete bands which surround them, (14-)15-17(-18) µm in diam.

Comments: It is close to *B. armillata* Nann.-Brem. (NANNENGA-BREMEKAMP, 1966), which has spores with a pale band, but the latter is longer than in *B. dearnessii*, besides, its spores are bigger. *B. armillata* is only known from the type described from the Netherlands, and more recently from Japan (NANNENGA-BREMEKAMP & YAMAMOTO, 1987), however, the pale band on the spores was not observed in this last case.

The presence of a pale band on the spores separates *B. dearnessii* from other species with big spores and without this band, such as *B. affinis* Rostaf., B. orbiculata Rex and *B. macrocarpa* (Ces.) Rostaf., NANNENGA-BREMEKAMP (op. cit.), pointed out that specimens with a stalk can be similar macroscopically to *Physarum compressumm* Alb. & Schwein.

KOWALSKI (1975) indicated the similarities of *B. goniospora* Meyl. with *B. dearnessii* which he considers as possible synonimous.

B. dearnessii was known before in Spain from Murcia (LOPEZ-SÁNCHEZ & al., 1986a) on dead wood of a lemon tree.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Figs. 1-5. *Badhamia dearnessii*: Sporocysts and spores (H.AH 11396).

CACERES: On wood of *Populus alba*, Cañameros, bank of river Ruecas, 23-IX-1988, H.AH 11396 (duplo in the private herbarium of Nannenga-Bremekamp, sub nº 16250), 11397 and 11398.

Badhamia foliicola Lister

CACERES: On bark of *Quercus suber*, estate "Las Cansinas" (Natural Park of Monfragüe), 29-XI-1988, H.AH 11457. On wood of *Populus alba*, river Ruecas, Cañameros, 23-IX-1988, H.AH 11359.

Badhamia gracilis (T. Macbride) T. Macbride.

Our specimen has bigger spores: ((18)19-20 µm in diam.) than those described by NANNENGA-BREMEKAMP (1974), of 12-16 µm in diam.

It grows on dead stems of *Yucca*, *Opuntia* and *Cactaceae*. Known before in Spain from Canarias (CHAMPION & BELTRAN, 1980; LADO & MORENO, 1981b) and Levante (GRACIA, 1981; GRACIA, 1983; HONRUBIA & al., 1984).

CANARIAS: On leaves and bark of *Opuntia ficus-indica*, Barranco de Guayadeque, Gran Canaria, 20-XII-1979, H.AH 11575.

Badhamia utricularis (Bull.) Berk.

CACERES: On a dead branch of *Alnus glutinosa*, Barbaón stream (Natural Park of Monfragüe), 22-XI-1985, H.AH 9540.

Ceratiomyxa fruticulosa (Müll.) T. Macbride.

This species is very common and cosmopolitan, it has been treated recently in the technical cards of CHASSAIN (1987). The variety *porioides* (Alb. & Schwein.) Lister has been reported from Cataluña in the series "Bolets de Catalunya" from the SOCIEDAD CATALANA DE MICOLOGIA (1986).

CACERES: On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 26-XI-1988, H.AH 11441.

Collaria rubens (Lister) Nann.-Brem.

C. rubens is characterized by its reddish-brown sporocysts. Stalk long, 0,5-1 mm in heigth. Peridium evanescent but persistent in its lower part as a reddish-brown membranous cup. Columella black. Capillitium formed by dark brown filaments which are ramificated and anastomosed. Spores brown-yellowish, spherical, slightly warted, 7-8,5 µm in diam.

It lives on dead leaves and bark. This species has been cited a few times for Spain: it is only known from the central zone (LADO, 1984; LADO, 1985), from Levante and Cataluña (GRACIA, 1981).

C. elegans (Racib.) Dhillon & Nann.-Brem. is close to this species but it differs from it in having a purple to lilaceous-brown colour and because the calyculus left by the peridium, is minute, not more than a small collar.

CACERES: On leaves of *Viburnum tinus* and *Quercus ilex* ssp. *rotundifolia*, umbria del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11349 (duplo in the private herbarium of Nannenga-Bremekamp sub nº 16252) and 11371.

Comatricha nigra (Pers.) Schröet.

CACERES: On living trunk of *Phoenix canariensis* with Epithele canariensis, Miajadas, 2-XI-1987, H.AH 10508, 10509 and 10510. On dead branch of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10884 and 10906. On dead branch of *Quercus suber*, road of La Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 22-II-1986, H.AH 10885. On wood of *Pinus pinaster*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11455.

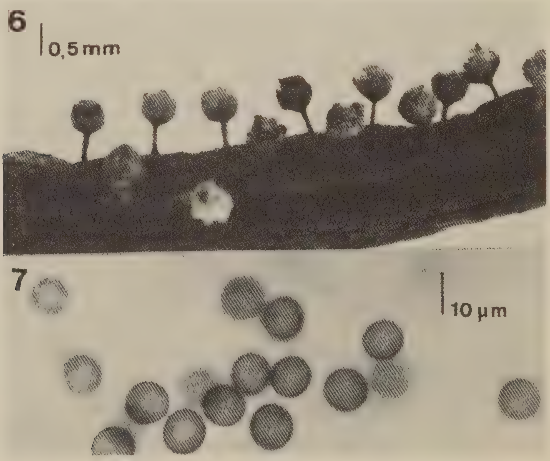
CUENCA: On wood of *Pinus pinaster*, Sotos, 26-X-1988, H.AH 11475. Idem, Uña, 27-X-1988, H.AH 11403.

MADRID: On wood of *Pinus halepensis*, Cuesta Zulema, Alcalá de Henares, 26-I-1989, H.AH 11565.

Craterium aureum (Schum.) Rostaf. (Figs. 6-7)

This yellow *Craterium* with folicolous habitat is only known in Spain from Baleares (GRACIA, 1981) and Barcelona (MALENÇON & BERTAULT, 1972), being widely distributed in the rest of the world (LISTER, 1925).

It shows some similarities with *Physarum sulphureum* Alb. & Schwein. because of its yellowish sporocysts which also have a star-shaped dehiscence, and because of the presence of a pseudocolumella, but it differs from it in having darker and bigger spores, and a whitish stalk similar to the one of *Didymium squamulosum* (Alb. & Schwein.) Fr.



Figs. 6-7. *Craterium aureum*: Sporocysts and spores (H.AH 11365).

CACERES: On leaves of *Viburnum tinus* and *Arbutus unedo*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11364, 11365 and 11385.

Craterium leucocephalum (Pers.) Ditmar **var. leucocephalum**
CACERES: On a leaf of *Quercus ilex* ssp. *rotundifolia*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11427.

Craterium leucocephalum (Pers.) Ditmar, **var. scyphoides** (Cooke & Balf.) G. Lister.
The variety *scyphoides* is characterized by its globose white-greyish sporocysts and by its hypotalus and brown-reddish stalk.

CACERES: On leaves of *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tormantós, 20-IV-1988, H.AH 10886.

Craterium minutum (Leers) Fr.
CACERES: On leaves of *Quercus ilex* ssp. *rotundifolia*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11427.

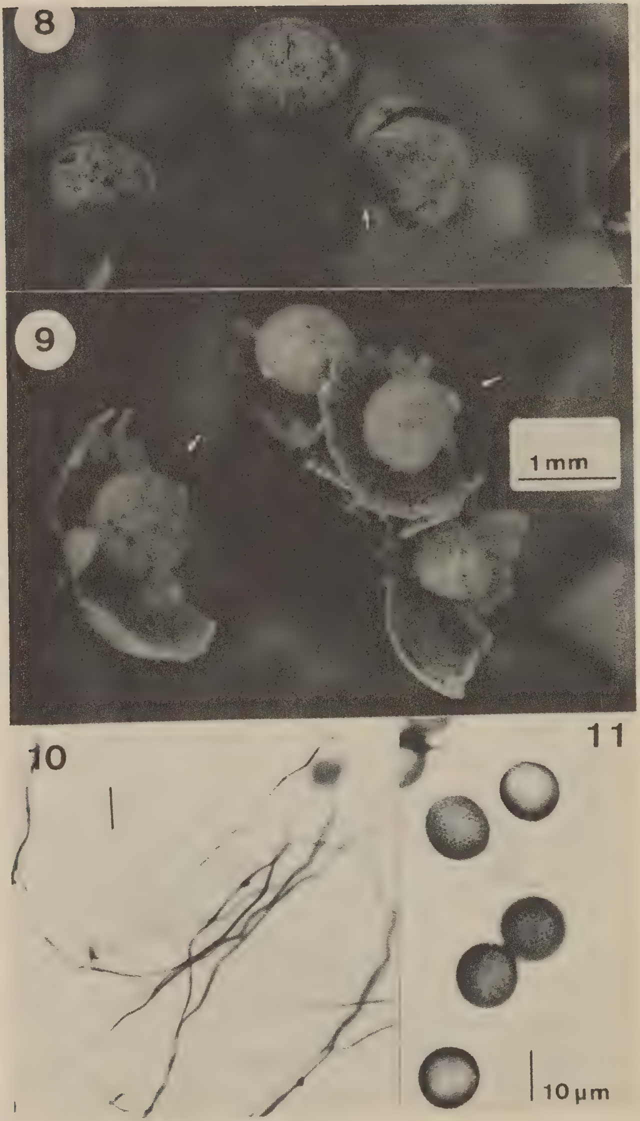
Cribraria argillacea (Pers.) Pers.
CACERES: On wood of *Pinus pinaster*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11376. Idem, Saltos de Torrejón (Natural Park of Monfragüe), H.AH 11375 and 11454.

Cribraria cancellata (Batsch) Nann.-Brem.
CACERES: On wood of *Pinus pinaster*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11430.

Diderma fragilis Arambarri, Bol. Soc. Argentina Bot. 15(2-3): 175-176 (1973). (Figs. 8-11)
It agrees macro- and microscopically with ARAMBARRI's (1973) description. It is characterized by its thick peridium, formed by two united layer, the outer calcareous and whitish, and the inner membranous with irregular dehiscence. Stalk short, with a characteristic reddish dark colour, wrinkled and becoming thinner towards the base. Columella globose and whitish. Capillitium abundant, filaments blackish, with small enlargements. Spores globose, spinulose, violaceous, 12-14 µm in diam.

Described from Argentina (Tierra de Fuego), on mosses and hepatics (ARAMBARRI, op. cit.), it has been found in Spain fruiting on living mosses in humid mountain zones. We do not know of any report of this species in Europe.

MADRID: On *Dicranum scoparium*, La Barranca de Navacerrada, 28-XI-1988, leg.: J. Álvarez, J.M. Barrasa & F. Esteve-Raventós, H.AH 11374 (duplo in the private herbarium of Nannenga-Bremekamp, sub nº 16248).


8
9
1 mm
10
11
10 µm

Figs. 8-11. *Diderma fragilis*: Sporocysts, capillitium and spores (H.AH 11374).

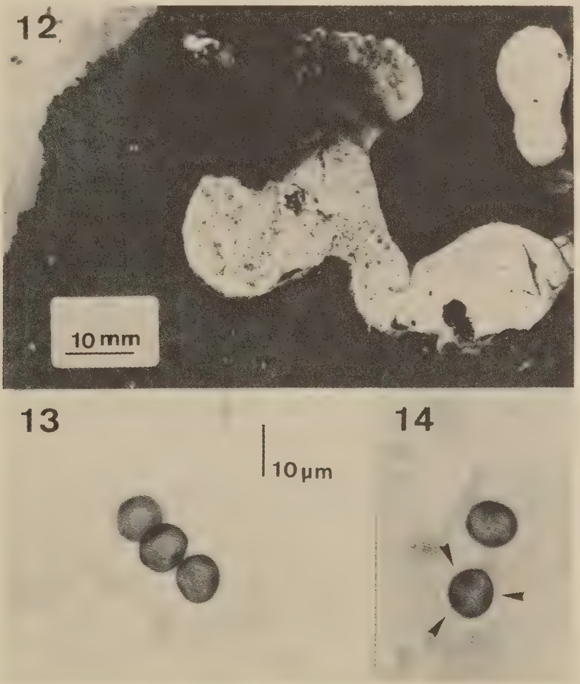
Diderma platycarpum Nann.-Brem., Proc. K. Ned. Akad. Wet. C. 69: 359. (1966). (Figs. 12-14)

D. platycarpum is characterized by its sessile and very thin plasmodiocarps. Peridium double, the outer layer white, calcareous as a shell; the inner fragile and membranous. Dehiscence irregular. Columella absent. Capillitium abundant, thin, ramifying dichotomously and united to the base of the peridium. Spores brown-purple under the microscope, finely warted, with groups of more pronounced warts, subglobose, 8,5-10 µm in diam.

It is close to *D. effusum* (Schwein.) Morgan, but the latter presents smaller spores and taller plasmodiocarps. Macroscopically it could be confused with some species of *Didymium* with a shell-like peridium.

According to the literature *D. platycarpum* has not been recorded previously in our country.

CACERES: On a leaf of *Viburnum tinus*, umbría del castillo (Natural Park of Monfragüe), H.AH 11360.



Figs. 12-14. *Diderma platycarpum*: plasmodiocarp and spores (H.AH 11360).

Diderma trevelyani (Grev.) Fr.
CACERES: On bark of *Pinus pinaster*, Saltos de Torrejón (Natural Park of Monfragüe), 20-IV-1988, H.AH 10904.

Didymium bahiense Gottsberger, *emmend.* Nann.-Brem.
D. bahiense is characterized by its greyish-white or pale grey discoid to subglobose sporocysts, umbilicate at the base. Stalk long, slightly bent at the apex, brown orange-coloured, paler in the upper part. Columella white, subglobose, pulvinate, flattened, rarely absent. Capillitium filaments ramificated, colourless to brown, often with small darker nodules. Spores brown-violaceous under the microscope, warted, with groups of more pronounced warts, 10-12 µm in diam.

The specimen H.AH 11401, collected in La Coruña, differs from the rest because of its bigger and flattened columella, agreeing with the iconography of Nannenga-Bremekamp (1974). The other collections present a smaller or non-existent columella.

CACERES: On wood of *Populus alba*, Cañameros, bank of river Ruecas, 23-IX-1988, H.AH 11348 and 11355.

LA CORUÑA: On dried stem of *Brassica oleracea*, Sionlla, 18-XI-1988, leg.: L. Cabo, H.AH 11401.

MADRID: On leaves of *Cercis siliquastrum* and needles of *Pinus pinea*, quinta "Cervantes", Alcalá de Henares, 15-V-1988, H.AH 11038. Idem, on leaves of *Morus* sp., 10-III-1989, H.AH 11569.

SEGOVIA: On branch of *Santolina rosmarinifolia*, mountain pass of Los Leones, 8-IV-1984, leg.: G. Moreno, H.AH 10926.

Didymium clavus (Alb. & Schwein.) Rabenh.
D. clavus is similar to *D. aquatile* Gottsberger & Nann.-Brem. in the discoid sporocysts, but can be differentiated by the dark base and stalk of the sporocyst and the absence of columella.

CACERES: On a leaf of *Quercus ilex* ssp. *rotundifolia* together with *D. melanospermum*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11353.

Didymium difforme (Pers.) Gray
CACERES: On wood of *Populus alba*, Cañameros, bank of river Ruecas, 23-IX-1988, H.AH 11348 and 11420.

MADRID: On leaves of *Morus nigra*, quinta "Cervantes", Alcalá de Henares, 10-III-1989, H.AH 11569.

Didymium eximium Peck
CACERES: On a leaf of *Viburnum tinus*, umbría del castillo de Monfragüe, 25-XI-1988, H.AH 11395.

CÓRDOBA: On a leaf of *Smilax aspera*, Priego de Córdoba, 2-IV-1988, leg.: J. Gómez, H.AH 11577.

Didymium melanospermum (Pers.) T. Macbride

CACERES: On leaves of *Quercus ilex* ssp. *rotundifolia*, *Salix* sp. and herbaceous rests, umbría del castillo (Natural Park of Monfragüe), 24-X-1986, H.AH 10892. Idem, on leaves of *Viburnum tinus*, *Quercus ilex* ssp. *rotundifolia*, *Arbutus unedo*, *Phyllirea angustifolia* and wood of a broad-leaved tree, 25-XI-1988, H.AH 11353, 11378, 11384, 11389, 11392, 11395 and 11408.

MADRID: On a leaf of a herbaceous plant, mountain pass of Canencia, leg.: F. Esteve-Raventós & J. Alvarez, 5-XI-1988, H.AH 11351.

Didymium minus (Lister) Morgan

CACERES: On leaves of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantos, 11-XI-1987, H.AH 10513, 10514, 10515 and 10516.

Didymium muscorum Lakhanpal & Mukerji.

CACERES: On bone of ruminant, Sierra de Lagunilla, 3-I-1988, leg. A. Acha, H.AH 10776. On a leaf of *Viburnum tinus*, *Phillyrea angustifolia* and *Quercus ilex* ssp. *rotundifolia*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11437 and 11363. On a dead branch of a fig-tree, obtained after incubation in moist chamber culture in the laboratory, Valdefuentes, 30-VIII-1988, leg.: J.L. Manjón, H.AH 11416.

Didymium nigripes (Link) Fr.

D. melanospermum (Pers.) T. Macbride and *D. minus* (Lister) Morgan are close to this species in that all three have a brown areolate peridium and have a brown and more or less globose columella. (NANNENGA-BREMEKAMP, 1972). *D. melanospermum* has bigger and darker spores and *D. minus* have shorter more opaque stalks.

CACERES: On leaves of *Viburnum tinus*, *Myrtus comunis*, *Arbutus unedo*, *Quercus suber*, *Quercus ilex* ssp. *rotundifolia*, *Quercus faginea* and wood of a broad-leaved tree, umbría del castillo (Natural Park of Monfragüe), 10-XI-1987, H.AH 10511 and 10512. Idem, 25-XI-1988, H.AH 11349, 11350, 11354, 11358, 11362, 11367, 11378, 11381, 11382, 11383, 11384, 11385, 11389, 11391 and 11395. On leaves of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11356 and 11357.

Didymium squamulosum (Alb. & Schwein.) Fr.

It is very close, macroscopically, to *D. muscorum* Lakhanpal & Mukerji, which has however bigger spores with a strong spinose ornamentation. It is also close to *D. simlensis* Lakhanpal & Mukerji, which is different because of its globose depressed and smaller sporocysts, double calcareous peridium, shorter columella and strongly spinose and reticulate spores of 9-12,5 µm in diam. (LAKHANPAL & MUKERJI, 1979).

CACERES: On dead leaves of *Arbutus unedo*, *Viburnum tinus*, *Phillyrea angustifolia*, *Myrtus comunis*, *Quercus suber* and *Quercus ilex* ssp. *rotundifolia*, umbría del castillo (Natural Park of Monfragüe), 10-XI-1987, H.AH 10517. Idem, 25-XI-1988, H.AH 11354, 11363, 11378, 11387, 11391, 11392, 11394, 11400 and 11402. On dead branch of *Eucalyptus camaldulensis*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10891.

Didymium trachysporum G. Lister

This species is easy to recognize by its sessile fructifications, pulvinated or hemisphaerical, even forming plasmodiocarps very like *D. difforme* (except for its very distinct spores). Peridium double, outer layer white as a shell. Spores purple-brown, with warts irregularly distributed, sometimes forming a pseudoreticulum, 9-10 µm in diam. It lives on dead leaves, stems of herbaceous plants and herbivorous dung.

TERUEL: On deer dung, obtained in culture, Orihuela del Tremedal, 5-V-1978, leg.: A. Bello, H.AH 11577.

Enerthenema papillatum (Pers.) Rostaf.

Characterized by its persistent peridium disc united apically to the columella. The recently described *E. intermedium* Nann.-Brem. & Critchfield is close to it, but it differs in having a deep apical funnel-shaped disc, capillitium arising from the whole columella and dark spores with a paler side (NANNENGA-BREMEKAMP & CRITCHFIELD, 1988).

BADAJOZ: On wood of a broad-leaved tree, Argallón stream, Azuaga, 12-X-1988, leg.: J.R. García, H.AH 11487.

Enteridium lycoperdon (Bull.) Farr

≡ Reticularia lycoperdon Bull.

CACERES: On cut trunk and bark of *Quercus suber*, road from la Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 6-III-1987, H.AH 10520. Idem, 12-III-1987, H.AH 10521. Idem, 18-V-1986, H.AH 10864. Idem, 21-IV-1988, H.AH 10894. On dried trunk of *Alnus glutinosa*, estate "Las Cansinas" (Natural Park of Monfragüe), 20-III-1987, H.AH 10522. On piled trunks of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10893. On bark of *Alnus glutinosa*, Barbaón stream (Natural Park of Monfragüe), 21-IV-1988, H.AH 10897.

Fuligo cinerea (Schwein.) Morgan

This rare species is only known in Spain from Canarias (ELIASSON & LUNDQUIST, 1979), Granada (LADO & al., 1980) and Madrid (MORENO & al., 1987), it is characterized by its small pulvinated aethalia, approximately 3-4 cm in diam. and whitish colour, which sometimes fructificate among herbaceous rests in the entrance of ants' nests.

CUENCA: On rests of *Poaceae* in an ant nest, Villalba de la Sierra, 26-X-1988, H.AH 11452.

Fuligo septica (L.) Wigg.

CACERES: On a stump of *Quercus ilex* ssp. *rotundifolia*, road from la Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 10-VIII-1986, H.AH 10519, leg.: A. Acha. Idem, on a stump of *Quercus suber*, 21-IV-1988, H.AH 10868, 10895 and 10896. On leaves of *Quercus pyrenaica*, Berzocana, 23-XII-1987, H.AH 10867.

CUENCA: On a trunk of *Pinus pinaster*, Sotos, 26-X-1988, H.AH 11439. Idem, Uña, 27-X-1988, H.AH 11404.

Leocarpus fragilis (Dickson) Rostaf.

BADAJOZ: On leaves of *Quercus ilex* ssp. *rotundifolia*, Azuaga, 14-II-1988, leg.: J.R. García, H.AH 10869.

CACERES: On a stem of a living *Cistus ladanifer*, Santibañez el Alto, 2-II-1988, H.AH 10775. leg. A. Acha & E. Soto. On a stem of a *Poaceae*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11422. Idem, on a stem of *Thymus* sp., 25-II-1988, leg.: J.L. Manjón, H.AH 11458.

GUADALAJARA: On rests of *Poaceae*, "El pinar", Sigüenza, 12-XI-1988, leg.: J. Álvarez & F. Esteve-Raventós, H.AH 11438.

MADRID: On needles of *Pinus pinaster*, embalse de Navalmedio, 1-VI-1988, leg.: M. Heykoop & F. Esteve-Raventós, H.AH 11431. On a trunk of *Thymus zygis*, Mountain pass of Canencia, 5-XI-1988, leg.: F. Esteve-Raventós & J. Álvarez, H.AH 11436. Idem, on leaves of *Cistus laurifolius*, H.AH 11440.

Licea variabilis Schrader.

CACERES: On wood of *Pinus pinaster*, mountain pass of Los Castaños, 26-XI-1988, H.AH 11417.

Lycogala epidendrum (L.) Fr.

BADAJOZ: On wood of a broad-leaved tree, Dehesa Vieja, Azuaga, 22-X-1988, leg.: J.R. García, H.AH 11453.

CACERES: On a stump of *Alnus glutinosa*, Barbaón stream (Natural Park of Monfragüe), 22-XI-1985, H.AH 9539. On a stump of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 9-IV-1987, H.AH 10525 and 10526. Idem, on piled trunks of *Pinus pinaster*, 24-XI-1988, H.AH 11426, 11434 and 11443. On wood of a broad-leaved tree, umbría del castillo (Natural Park of Monfragüe), 24-X-1986, H.AH 10870. On piled trunks of *Pinus pinaster*, Saltos de Torrejón (Natural Park of Monfragüe), 22-IV-1988, H.AH 10871. On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11412.

Lycogala flavofuscum (Ehrenb.) Rostaf.

In Spain, it is a rare species, almost always associated with leaves and woody rests of the genus *Populus*, while in other countries it often occurs in rotting wood in living trees. Only known from Madrid (several reports) and País Vasco (Mycological Catalogue of the País Vasco, 1981).

It is characterized by its big aethalia mostly 3 cm (or more) in diam. Cortex thick, smooth and pseudocapillitium formed by thick tubules.

CACERES: On wood of *Quercus suber*, road from la Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 18-V-1986, H.AH 10872.

Metatrichia vesparium (Batsch) Nann.-Brem.

CACERES: On bark of *Quercus suber*, estate "Las Cansinas" (Natural Park of Monfragüe), 29-XI-1988, H.AH 11444 and 11445.

CANARIAS: On wood, Cedro stream, La Gomera, 11-III-1989, leg.: A. Acha, H.AH 11571.

Mucilago crustacea Wigg.
CACERES: On herbaceous rests, Berzocana, 23-XII-1987, leg.: F. Durán, H.AH 10873. On woody rests, umbría del castillo (Natural Park of Monfragüe), 24-X-1986, H.AH 10877. On a frond of a fern, Valle del Jerté, Los Pilones, 13-IX-1988, leg.: A. Acha, H.AH 11447.

Perichaena chrysosperma (Currey) Lister
CACERES: On wood of *Populus alba*, bank of river Ruecas, Cañameros, 23-IX-1988, H.AH 11377.

Perichaena depressa Libert.
This species is characterized by its depressed sporocysts which are in dense groups producing a typical polygonal or tesselate appearance, dark brown, dehiscence circumscissile along preformed lines, capillitium annulated, and spores warted, 10,5-12 μm in diam.

CACERES: On wood of *Populus alba*, bank of river Ruecas, Cañameros, 23-IX-1988, H.AH 11377.

Perichaena pedata (Lister & G. Lister) G. Lister. 1937.
= Perichaena variabilis Rostaf. var. pedata Lister & G. Lister.
= Perichaena minor (G. Lister) Hagelst..
CACERES: On cladodes and dried nerves of *Opuntia ficus-indica*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 10-IV-1987, H.AH 10523 and 10524.

Physarum bitectum G. Lister.
This species has sporocysts or short plasmodiocarps, white, 0,5-1 mm in diam. Peridium double, exoperidium calcified, white; endoperidium membranous, violaceous-brown. Capillitium with numerous rounded nodes. Spores purple-brown, spinulose, with zones of more pronounced ornamentation, 9,5-11 μm in diam.

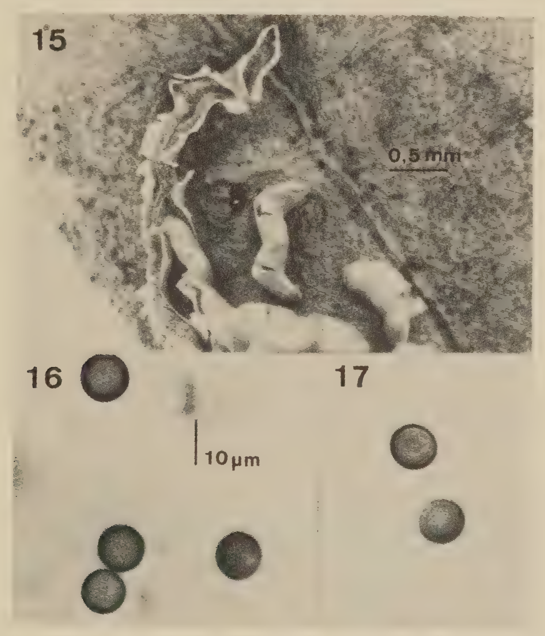
P. bitectum is a species which has not often been cited in the spanish literature. *P. bogoriense* Racib. differs because of its dark yellowish plasmodiocarps and its smaller and evenly warted spores. Macroscopilcally it may be similar to *P. cinereum* (Batsch) Pers., *P. vernum* Sommerf. and to *P. bivalve*.

CACERES: On a leaf of *Arbutus unedo*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11361.

Physarum bivalve Pers.
CACERES: On leaves of *Quercus ilex* ssp. *rotundifolia*, *Quercus faginea*, *Myrtus communis*, *Phillyrea angustifolia and Viburnum tinus*, umbria del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11414, 11423, 11407 and 11437.

Physarum bogoriense Racib., Hedwigia 37:52. 18 F. (1898).(Figs. 15-17)
= Physarum pallidum Lister, Jour. Bot. 36:117. Ap. (1898).
This species forms extended tortuous and dark brown to yellowish plasmodiocarps (as in *Badhamia crassipella* Whitney & Keller). Peridium

triple, the outer yellowish or brown, cartilaginous, the middle white, with the same consistence and the inner membranous, iridescent. During the dehiscence both layer are separated forming triangular lobes, the inner often is evanescent and is lost. Capillitium hyaline, ramificated, with calcareous nodes. Spores dark brown in mass, brown-violaceous under the microscope, minutely warted, 9-10 µm in diam. It grows on dead leaves.



Figs. 15-17. *Physarum bogoriense*: plasmodiocarps and and spores (H.AH 11429).

According to the literature *P. bogoriense* Racib. is a new contribution to the spanish catalogue of *Myxomycetes*.

It is different from *P. bivalve* Pers. because of its dehiscence forming more or less triangular lobes instead of valves as happen in the latter, it also differs in its typical dark yellowish colour and its minutely warted spores. Besides, it is different from *P. bitectum* G. Lister because of its white plasmodiocarps and its clearly spinose spores of 10-13 µm in diam. WHITNEY & KELLER (1982) have recently described the species *Badhamia crassipella* which was included in the description of *P. bogoriense* by MARTIN & ALEXOPOULOS (1969:289). A study of the american collections made them split off this new species of *Badhamia*. The long and often reticulated plasmodiocarps of *B. crassipella* are bigger than the sporocysts and short plasmodiocarps of

P. bogoriense. The lobulate dehiscence of *P. bogoriense* is clearly different from the irregular dehiscence of *B. crassipella*. Finally, *P. bogoriense* has a "physaroid" capillitium and free spores whereas *B. crassipella* has a "badhamioid" capillitium and spores interlocked by their warts in clusters of 4-40 spores (WHITNEY & KELLER, op. cit.)

CACERES: On leaves of *Quercus ilex* ssp. *rotundifolia* and *Viburnum tinus*, umbría del castillo (Natural Park of Monfragüe), 25-XI-1988, H.AH 11407 and 11429.

Physarum compressum Alb. & Schwein.

MADRID: On leaves of *Cercis siliquastrum*, *Morus* sp. and needles of *Pinus pinea*, quinta "Cervantes", Alcalá de Henares, 15-V-1988, H.AH 11038. Idem, 10-III-1989, H.AH 11567, 11568, 11570 and 11573.

Physarum contextum (Pers.) Pers.

CACERES: On wood of *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tormantos, 28-XI-1988, H.AH 11425.

Physarum leucophaeum Fr.

CACERES: On a stump of *Quercus suber*, estate "Las Cansinas" (Natural Park of Monfragüe), 23-X-1986, H.AH 10878. Idem, road from La Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 12-III-1987, H.AH 11012. On wood of *Arbutus unedo*, umbría del castillo (Natural Park of Monfragüe), 24-X-1988, H.AH 10888.

MADRID: On wood of *Fagus sylvatica*, mountain pass of La Quesera, 6-IX-1988, H.AH 11418.

Physarum nutans Pers.

BADAJOZ: On decayed wood, Argallón stream, Azuaga, 20-III-1988, leg.: J.R. García, H.AH 10882. Idem, on wood of a broad-leaved tree, 1-V-1988, leg.: J.R. García, H.AH 11442, 11446, 11449 and 11486. Idem, on *Quercus* sp., 9-VI-1988, leg.: J.R. García, H.AH 11411.

CACERES: On wood of *Alnus glutinosa*, Barbaón stream (Natural Park of Monfragüe), 12-III-1987, H.AH 10518. Idem, Malvecino stream (Natural Park of Monfragüe), 20-III-1987, H.AH 10527. On wood of *Arbutus unedo*, *Quercus ilex* ssp. *rotundifolia* and *Quercus suber*, growing together with *Helotium fructigenum*, umbría del castillo (Natural Park of Monfragüe), 24-X-1986, H.AH 10881. On bark of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10879. Idem, on a dead branch of *Eucalyptus camaldulensis*, H.AH 10865, 10880 and 10887. On *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 26-XI-1988, H.AH 11405 and 11459. Idem, 28-XI-1988, H.AH 11423 and 11460.

MADRID: On a leaf of *Quercus pyrenaica*, Montejo de la Sierra, leg.: J.M. Barrasa, F. Esteve-Raventós & A. Andrade, 30-IX-1987, H.AH 11388. On wood of *Pinus halepensis*, Cuesta Zulema, Alcalá de Henares, 26-I-1989, H.AH 11572.

PONTEVEDRA: On wood of *Pinus* sp., Villagarcía de Arosa, 18-XI-1988, leg.: agrupación Micológica de Villagarcía, H.AH 11409.

Physarum robustum (Lister) Nann.-Brem.

BADAJOZ: On a branch of a broad-leaved tree and on *Trametes versicolor*, Argallón stream, Azuaga, 24-III-1988, leg.: J.R. García, H.AH 10777.

Physarum viride (Bull.) Pers.

CACERES: On woody rests of *Arbutus unedo*, umbría del castillo (Natural Park of Monfragüe), 24-X-1986, H.AH 10888.

Stemonitis axifera (Bull.) T. Macbride.

CACERES: On piled trunks of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10889, 10890, 10898, 10900, 10985 and 10987. Idem, 24-XI-1988, H.AH 11390, 11399, 11419, 11421, 11461, 11462, 11466, 11467, 11468, 11473 and 11474. Idem, umbría del castillo de Monfragüe, 25-XI-1988, H.AH 11366. On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11424.

Stemonitis flavogenita Jahn.

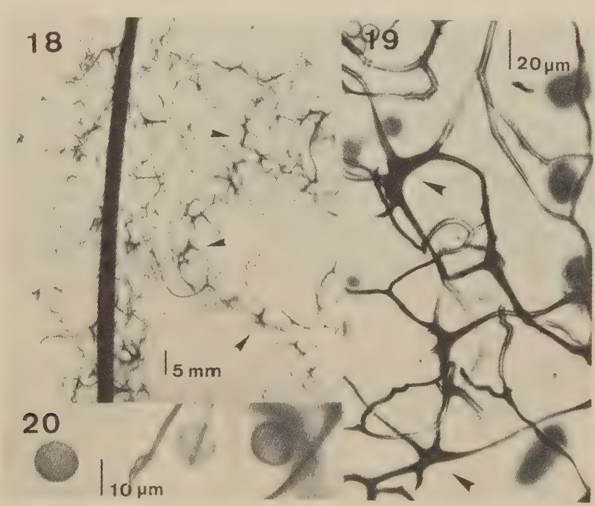
CACERES: On a dead trunk of *Eucalyptus camaldulensis*, Mountain pass of los Castaños, 26-XI-1988, H.AH 11368.

Stemonitis fusca Roth.

BADAJOZ: On woody rests, stream Argallón, Azuaga, 20-III-1988, leg.: J.R. García, H.AH 10903. Idem, on wood of *Quercus* sp., 20-V-1988, H.AH 11476.

CACERES: On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 26-XI-1988, H.AH 11406.

Stemonitis splendens Rostaf., Mon.: 195. 1874. **var. webberi** (Rex) Lister, Mycet, 112. (1894). (Figs. 18-20)
= Stemonitis webberi Rex. Proc. Acad. Phila. 43: 390. (1891).



Figs.18-20. *Stemonitis splendens* var. *webberi*: capillitium and spores (H.AH 11372).

S. splendens is characterized by its dark purplish to black sporocysts, of 7-15 or more mm in height, by its capillitium which is usually scanty internally and perpendicular to the columella and forms a wide smooth superficial net of rounded meshes and by its warted spores of 7-9 µm in diam. The variety *webberi* is characterized by the branches of the capillitium which are thicker than in the type-variety and which emerge from the columella in a non-perpendicular way, by its smaller size and the more angular meshes of the capillitium surface net. Our collection agrees with the figure by NANNENGA-BREMEKAMP (1974).

It can be confused with poor specimens of *Symphytocarpus flaccidus* (Lister) Ing. & Nann.-Brem. The variety *splendens* has been cited in Spain from the País Vasco (A.E.P.N.A., 1976; LADO & MORENO, 1981a; Mycological Catalogue of the País Vasco, 1981), Barcelona (GRACIA, 1981) and Canarias (CHAMPION & BELTRAN, 1980). Our report of the var. *webberi* is the first record for Spain.

CASTELLÓN: On a trunk of *Pinus halepensis*, Oropesa del Mar, 8-IX-1988, H.AH 11372.

Stemonitis virginiensis Rex.
CACERES: On piled trunks of *Pinus pinaster*, mountain pass of La Cañadilla (Natural Park of Monfragüe), 21-IV-1988, H.AH 10907.

Stemonitopsis typhina (Wigg.) Nann.-Brem.
Recently, (NANNENGA-BREMEKAMP & YAMAMOTO, 1987) have discussed the var. *similis* (G. Lister) Nann.-Brem. & Y. Yamam., which is different from the type-variety because of the lack of a silvery membrane on the stalk and because of its different and more delicate capillitium

BADAJOZ: On wood of a broad-leaved tree and a dead *Poliporaceae*, Argallón stream, Azuaga, 21-V-1988, leg.: J.R. García, H.AH 11450.

CACERES: On *Quercus suber*, road from la Bazagona to estate "Las Cansinas" (Natural Park of Monfragüe), 12-III-1987, H.AH 10528.

Symphytocarpus flaccidus (Lister) Ing & Nann.-Brem.
CACERES: On piled trunks of *Pinus pinaster*, Presa de Torrejón (Natural Park of Monfragüe), 20-IV-1988, H.AH 10986.

MADRID: On needles of *Pinus pinaster*, Mirador de los Robledos, 1-VI-1988, leg.: M. Heykoop & F. Esteve-Raventós, H.AH 11379.

Trichia botrytis (J.F. Gmelin) Pers.
SALAMANCA: On a trunk of *Castanea sativa* among mosses and lychens, Candelario, 5-II-1989, leg.: A. Acha, H.AH 11574.

Trichia contorta (Ditmar) Rostaf.
CACERES: On wood of *Eucalyptus camaldulensis*, mountain pass of Los Castaños, 28-XI-1988, H.AH 11428.

Trichia decipiens (Pers.) T. Macbride **var. decipiens**.

BADAJOZ: On wood of *Quercus ilex* ssp. *rotundifolia*, Argallón stream, Azuaga, leg.: J.R. García, 21-V-1988, H.AH 11413.

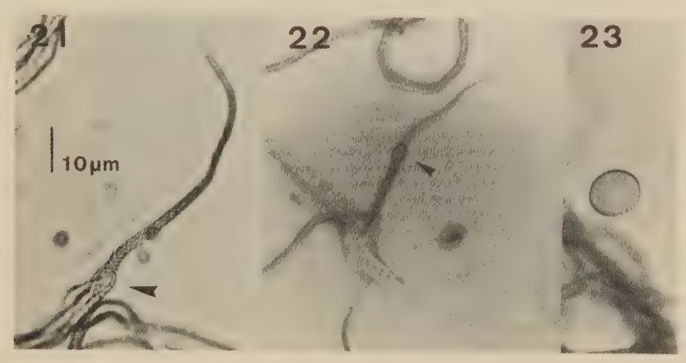
CACERES: On wood of *Arbutus unedo*, umbria del castillo (Natural Park of Monfragüe), 13-III-1987, H.AH 10529 and 10530.

Trichia decipiens (Pers.) T. Macbride **var. olivacea** Meyl.

CACERES: On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 20-IV-1988, H.AH 10901 and 10908. On wood of *Alnus glutinosa*, Barbaón stream (Natural Park of Monfragüe), 13-III-1987, H.AH 10531. On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11415 and 11451.

Trichia flavicoma (Lister) Ing, Trans. Br. Mycol. Soc. 50: 558. (1967). (Figs. 21-23)
= Trichia botrytis (J.F. Gmelin) Pers. var. flavicoma Lister, Mycet. ed. 1: 172. (1894).

T. flavicoma is characterized by its stalked dark reddish sporocysts of 1 mm in height. Peridium double with "petaloid" dehiscence along a yellow line. Capillitium abundant, yellowish, with enlargements and gradually narrowed ends with an ornamentation formed by 4-5 spirals. Spores yellow, warted, 9-10 µm in diam. (13-14 µm according to NANNENGA-BREMEKAMP, 1974).

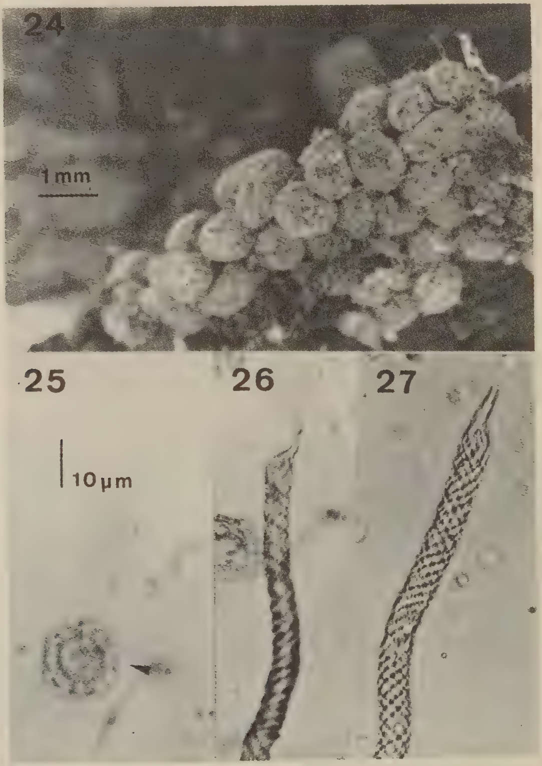


Figs. 21-23. *Trichia flavicoma*: capillitium and spores (H.AH 11372).

ING (1967) pointed out that *T. flavicoma* is different from *T. botrytis* because of its small size, black peridium, "petaloid" dehiscence along preformed yellow lines, and its yellow golden spores and elaters, and its folicolous habitat, especially on leaves of holly trees.

CACERES: On leaves of *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tormantós, 20-IV-1988, H.AH 10863.

Trichia persimilis Karsten (Figs. 24-27)
BADAJOZ: On burned wood of a broad-leaved tree, Argallón stream, Azuaga, 10-III-1988, leg.: J.R. García, H.AH 10902.
CACERES: On wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós, 28-XI-1988, H.AH 11369.



Figs. 24-27. *Trichia persimilis*: sporocysts, spore and apices of elaters (H.AH 11369).

Trichia varia (Pers.) Pers.
CACERES: On a branch of *Quercus suber*, Portillo del Salto del Gitano (Natural Park of Monfragüe), 22-II-1986, H.AH 10899.

Tubifera ferruginosa (Batsch) J.F. Gmelin
AVILA: On a cut down trunk of *Pinus pinaster*, Casavieja, 4-VI-1988, leg.: P. Sánchez & B. Fransesch, H.AH 11046.
CACERES: On a trunk of *Pinus pinaster*, Saltos de Torrejón (Natural Park of Monfragüe), 26-IV-1989, H.AH 116332.

ACKNOWLEDGEMENTS

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A STUDY OF HYPHAL MORPHOLOGY IN THE FORM GENUS RHIZOCTONIA

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SUMMARY

The morphology of the main hyphae, branch hyphae, and monilioid cells of several isolates referred to *Rhizoctonia* s.l. was investigated. This was done to evaluate their usefulness in the taxonomy of the form genus in order to identify several isolates occurring as orchid mycorrhiza. Identification was not possible as there was large variation and inconsistency in all characters studied, both within isolates and between cultures, and this variation was media-dependent. This variation made a comparison of isolates with the type descriptions impossible and throws doubt on the usefulness of most type descriptions.

INTRODUCTION

Duggar (1915) demonstrated a number of characters which could be used to distinguish Rhizoctonia crocorum DC. ex Fr. from R. solani Kühn, the identification of Rhizoctonia species has been based mainly on structures observed on mycelia grown in vitro. The form genus as presently circumscribed consists of vegetative mycelia having several of the following characteristics: coloured, septate, relatively wide main hyphae; side branches originating at an acute or right angle in the distal part of the cell, constricted at the point of origin and with a septum formed close to the main hypha; formation of monilioid cells, and formation of sclerotia.

In view of the studies of specificity between orchids and fungi (Warcup 1981), an identification of several isolates obtained from orchids and tentatively referred to *Rhizoctonia* was necessary. Since very different media have been employed for the type descriptions (Wolff 1926, Castellani 1935, Burgeff 1936, Saksena & Vaartaja 1960), and media-dependent development has been shown for some isolates (Wolff 1926, Saksena & Vaartaja 1960) it was necessary to grow the fungi on different substrates to monitor the hyphal characters of *Rhizoctonia*.

Classification of higher fungi is mainly based on teleomorph characters. However, teleomorphs can only be induced in about 60% of the *Rhizoctonia* isolates (Warcup 1981). A parallel identification of the anamorph state is still necessary.

Septal pore structure is considered to be very important in the taxonomy of fungi (Tu et al. 1977, Khan & Kimbrough 1982, Moore 1985). *Rhizoctonia* has been divided into five genera on the basis of pore structure and number of nuclei per cell (Yang & Korf 1985, Moore 1987), which brings the classification of the anamorphs more in line with that of the teleomorphs (Moore 1987).

This study evaluates the stability of hyphal morphology of *Rhizoctonia* s.l. by statistical treatment of some of the characters traditionally used in the identification of

TABLE 1

List of isolates. The CBS isolates were obtained from the Centraal Bureau voor Schimmelcultures, Baarn, The Netherlands. The names are those listed in the CBS catalogue. The D-numbered isolates have been isolated from roots or protocorms of european terrestrial orchids at the Botanical Laboratory, University of Copenhagen.

CBS 116.12..*Rhizoctonia anomala* Burgeff, ex *Orchis maculata*.
CBS 119.12..*R. stahlii* Burgeff, ex *Platanthera chlorantha*.
CBS 116.20..*R. mucoroides* Bernard, ex *Phalaenopsis schilleriana*.
CBS 162.24..*R. crocorum* (Pers.) D.C. ex Fr., ex *Solanum tuberosum*.
CBS 155.38..*Sistotrema brinkmannii* (Bres.) J.Erikss., ex *O. mascula*.
CBS 326.47..*R. repens* Bernard, ex *Orchis morio*.
CBS 214.61..*Tulasnella fusco-violacea* Bres., ex *Fagus sylvatica*.
CBS 758.79..*Ceratobasidium ramicola* Tu et al., ex *Pittosporum* sp.
CBS 476.82..*C. cornigerum* (Bourd.) Rogers, ex *Glycine* sp.
CBS 701.82..*R. versicolor* Müller & Nüesch, ex *Himantoglossum hircinum*.
CBS 178.83..*R. solani* Kühn, ex *Gladiolus* sp.
D47-5.......ex *Dactylorhiza* sp. Botanic Garden (BG),Copenhagen, 1985.
D47-6.......Same as above.
D47-7.......Same as above.
D59-1.......ex *Orchis sancta*, BG Nº P1969/5107,1985.
D85-3.......ex *Goodyera repens*, Tibirke Bakker, DK, 1985.
D93-1.......ex *D. majalis*, Tryggevælle å, DK, .
D94-1.......ex *D. incarnata*, Tryggevælle å, DK, 1985.
D102-3......ex *D. incarnata*, Holmegaards mose, DK, 1985.
D113-1......ex *Platanthera* sp., Öland, S, 1985.
D131-1......ex *Listera ovata*, Alindelille, DK, 1985.
D132-2......ex *Ophrys insectifera*, Alindelille, DK, 1985.
D145-1......ex *Orchis morio*, Frederikssund, DK, Jun. 1985.
D145-4......ex *Orchis morio*, Frederikssund, DK, Dec. 1985.
D145-13.....Same as above.
D186-1......ex *Orchis mascula*, Öland, S, 1986.
D188-5......ex *G. repens*, Öland, S, 1986.
D194-1......ex *D. incarnata*, Öland, S, 1986.
D197-3......ex *Orchis militaris*, Öland, S, 1986.
D227-4......ex *Gymnadenia conopsea var. densiflora*, Uppsala, S, 1986.

Rhizoctonia species. The sclerotia which consists of aggregations of monilioid cells were investigated by Tu & Kimbrough (1975) and will not be treated further here. Very few isolates actually produced sclerotia under the growth conditions employed in this study.

MATERIALS AND METHODS

Reference cultures were obtained from the Centraalbureau voor Schimmelcultures (CBS), Baarn, The Netherlands, and the D-numbered cultures were isolated at the Botanical Laboratory, Copenhagen from European terrestrial orchids (TABLE 1). The latter were obtained from roots or protocorms, which had been thoroughly washed in tap water. Thin slices were cut, hyphal balls were teased out from the cells, and the hyphal balls were washed two or three times in sterile water.

Single hyphal balls were transferred to the isolation medium, CM1, modified after Clements & Ellyard (1979), consisting of: 0.2 g/l $Ca(NO_3)_2.4H_2O$, 0.2g/l KH_2PO_4, 0.1 g/l KCl, 0.1 g/l $MgSO_4.7H_2O$, 0.1 g/l Difco Yeast Extract, 4.0 g/l Sucrose, 0.05 g/l novobiocin, and 12 g/l Difco Bacto-agar. The pH was adjusted to 6.8 before autoclaving. The growth medium, CM2, was without antibiotics, but otherwise like CM1.

Slide cultures (Burpee et al. 1980) were used for the measurements of cell length and distance between the branch insertions on the main hyphae. Water-agar (WA) (1.5% Difco Bacto-agar per liter of double-distilled water), or 2% Difco Potato Dextrose Agar (PDA) was poured in a thin layer on a sterile slide. One 25 mm^2 agar block cut from the edge of a growing mycelium was used as inoculum. The slides were incubated at room temperature in a moist chamber, until the colony was larger than 2 cm in radius, the slides were stained with acridine orange (Yamamoto & Ushida 1982) and observed with a Reichert-Jung Polyvar microscope with epifluorescence equipment (exiter filter BP 450-495nm, barrier filter LP 520nm). In some cases where septation was difficult to observe with acridine orange, the slides were also viewed either unstained or stained with aniline blue-black (ABB) (0.1% ABB in 7% acetic acid) with Nomarski interference contrast optics (IC) or normal light microscopy (LM).

For the production of monilioid cells, the fungi were grown on four different media: 1% and 2% PDA, CM2, and WA. The cultures were grown for up to 12 weeks at room temperatures. The minimum and maximum length and width of the cells were recorded from more than hundred observations. The mean was estimated as the average of minimum and maximum, assuming a normal distribution. The terminology of Stearn (1966) was used for morphological shapes. When the shape varied considerably, and did not fit any group, the cells were said to be irregular.

A main hypha is defined as the axis in a monopodium which measured from the perifery spans more than 50% of a mature mycelium not less than 2cm in radius. The definition of a mature mycelium is according to Bull & Trinci (1977).

Branching frequency is defined as the ratio: cell length/ branch distance. When the branching frequency is 1, there is a regular pattern of one branch per cell.

Cell length and distance between side branches are measured from the outermost elements of the main hyphae. All branch distances were recorded, including the very minute, when two branches are inserted almost oppositely.

NWA STATPAK, Multi-Function Statistics, Version 3.1, was used for the statistical treatment of the data.

In nine selected isolates three hyphae on PDA and WA were measured for 10 cell lengths and branch distances respectively. The means of cell length and branch distance were compared with a one factor analysis of variance (df=27, k=3). The null hypothesis is that the means for the three hyphae measured are the same. If the null hypothesis must be rejected the three hyphae cannot be represented by the common mean in other tests.

The similarity of cell length and the distance between branches was tested with a t-test for related samples. The null hypothesis is that cell length and branch distance is equal, i.e. branching frequency is 1. The isolates are represented by their common mean (df=29), except when the hyphae in one isolate were significantly different with regard to either cell length or branch distance, in which case the hyphae are treated separately (df=9).

The t-test for unrelated samples is used to compare cell length and distances between branches respectively on the

TABLE 2
Width of the main hyphae. The range is taken from 30 measurements, on three hyphae in ten different microscopic slide-cultures on WA. [1] taken from nine slide-cultures, [2] taken from seven slide-cultures. All measurements in µm.

Isolate	Width	Isolate	Width
CBS116.12[1]	6.9-12.0	D85-3	5.6-8.4
CBS119.12	3.2-5.6	D93-1	2.4-4.8
CBS116.20	4.0-6.4	D94-1	2.4-5.6
CBS162.24[2]	3.2-6.9	D102-3	5.6-8.0
CBS155.38	1.6-3.2	D113-1	6.4-8.0
CBS326.47	3.2-4.8	D131-1	2.4-4.8
CBS214.61	4.8-10.4	D132-2	3.2-5.6
CBS758.79	4.0-4.8	D145-1	3.2-5.6
CBS476.82	4.0-5.6	D145-4	3.2-5.6
CBS701.82	3.2-7.2	D145-13	2.4-4.8
CBS178.83	4.8-10.4	D186-1	3.2-4.8
D47-5	3.2-5.6	D188-5	3.2-6.4
D47-6	4.0-5.6	D194-1	3.2-4.8
D47-7	3.2-4.8	D197-3	3.2-5.6
D59-1	3.2-6.4	D227-4	5.6-8.8

two media, 2% PDA and WA (computed approximated df=30-60 (no influence on the significance level)). The null hypothesis is that the two media do not influence the cell length or branch distance.

The significance levels are shown as *,**, and *** for 5%, 1%, and 0.1% respectively according to tables in Campbell (1981).

RESULTS

A few *Rhizoctonia* isolates have characteristical narrow (CBS155.38) or wide (CBS116.12, CBS214.61 and CBS178.83) main hyphae, although the range of measurements of the latter three isolates overlap with several others (TABLE 2).

Fig.1 shows the differences between hyphal width measured in seven reference cultures and the measurements given in the original descriptions for these species (the type descriptions for the rest of the reference cultures did not contain information about hyphal width).

Fig.1

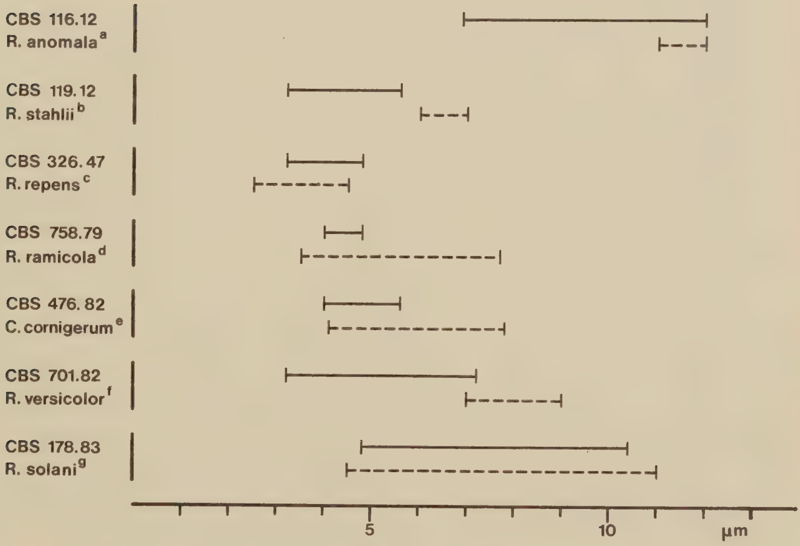


Fig.1. Main hyphal width of seven reference cultures (full bars) compared with literature records for the species to which the cultures are referred in the CBS catalogue (broken bars). The literature used is: a & b: Burgeff (1936), c & g: Saksena & Vaartaja (1961), d: Weber & Roberts (1951), e: Tu & Kimbrough (1975), f: Müller & Nüesch in: Gäumann et al. (1960). The range observed is taken from 30 measurements, three on each of 10 hyphae.

TABLE 3
List of mean length of 10 cells and corresponding mean distance between insertion of 10 branches on three different hyphae in each mycelium, except * calculated from four measurements. All measurements in µm.

	Cell length						Branch distance					
	PDA			WA			PDA			WA		
Hypha no.	1	2	3	1	2	3	1	2	3	1	2	3
Isolate												
CBS116.12	171.0	165.0	218.1	109.5	84.0	87.3	220.8	213.6	190.8	81.6	180.3	321.0
CBS119.12	306.4	268.0	316.0	269.6	421.6	451.2	800.0	728.8	661.6	338.4	438.4	328.8
CBS116.20	202.8	248.1	192.3	224.4	184.8	173.4	201.9	298.5	212.1	421.5	246.3	204.3
CBS162.24	42.3	57.0	99.3	69.9	95.4	84.0	108.0	105.6	106.5	94.2	594.0*	223.2
CBS155.38	141.2	138.2	155.0	84.3	94.8	81.6	274.5	301.8	285.6	111.6	75.6	89.1
CBS326.47	204.6	142.2	116.1	170.1	93.9	147.6	266.7	324.0	336.9	256.2	193.5	220.8
CBS214.61	60.6	60.6	66.3	91.5	89.4	87.3	46.5	66.0	92.4	118.8	121.5	226.5
CBS758.79	225.9	163.8	204.0	207.9	233.7	207.6	220.5	164.1	203.4	208.2	233.4	208.2
CBS476.82	232.2	218.1	204.9	160.2	141.9	122.4	133.8	79.5	150.0	159.3	191.4	150.9
CBS701.82	28.6	43.0	16.8	23.6	22.0	23.5	276.9	358.5	60.3	54.0	40.5	45.3
CBS178.83	235.2	205.6	236.8	312.8	285.6	296.8	402.4	394.4	453.6	278.4	286.4	296.8
D47-5	182.7	134.1	179.4	144.6	140.4	205.5	380.4	334.4	332.8	282.4	175.2	299.2
D47-6	140.4	199.5	198.9	128.7	150.6	187.2	534.4	412.8	322.4	200.8	220.0	253.6
D47-7	163.2	136.2	146.4	168.0	178.2	171.6	488.8	520.8	440.0	388.0	444.0	264.8
D59-1	144.3	146.7	114.9	117.6	123.3	102.6	188.1	197.1	198.3	199.8	160.2	122.1

TABLE 3 (continued)

	Cell length						Branch distance					
	PDA			WA			PDA			WA		
Hypha no.	1	2	3	1	2	3	1	2	3	1	2	3
Isolate												
D85-3	353.2	356.8	290.8	276.0	264.9	320.7	416.4	421.2	240.0	298.8	289.2	380.1
D93-1	255.3	269.4	286.5	328.8	291.0	309.0	257.4	270.0	310.5	326.4	237.3	309.0
D94-1	259.8	265.5	241.5	261.3	320.4	316.2	264.9	265.5	240.0	198.3	162.3	188.7
D102-3	411.0	401.4	409.5	460.8	478.8	434.7	410.4	435.3	406.2	460.8	481.8	391.8
D113-1	243.3	230.1	255.6	432.6	453.0	405.6	242.4	231.3	255.9	382.8	453.3	350.4
D131-1	63.3	74.7	79.2	67.8	56.7	65.4	118.8	117.3	142.2	119.4	100.8	191.1
D132-2	66.6	49.2	54.9	81.8	44.7	27.6	215.7	232.8	120.3	367.2	325.5	157.5
D145-1	124.2	109.2	74.1	85.5	50.1	61.2	473.4	453.0	374.1	384.9	339.9	454.5
D145-4	105.9	78.3	94.8	100.5	94.5	66.3	236.4	306.9	267.6	308.0	214.4	206.4
D145-13	184.5	127.8	236.4	147.3	175.8	135.9	334.4	207.2	348.0	173.7	223.2	173.4
D186-1	143.4	134.1	121.5	120.0	157.5	119.4	332.7	637.2	602.7	300.0	297.3	217.2
D188-5	365.6	362.4	323.2	229.6	237.6	158.4	365.6	362.4	323.2	229.6	237.6	177.6
D194-1	272.1	252.3	261.3	320.4	276.0	283.8	273.9	245.1	262.8	243.9	218.4	234.0
D197-3	132.0	124.8	115.5	73.8	82.2	103.8	307.8	262.2	143.1	163.8	174.0	234.9
D227-4	59.7	77.4	69.6	63.0	50.1	82.8	77.7	138.0	118.8	525.3	452.7	475.8

Mean cell length and branching frequency of main hyphae of the cultures grown on PDA and WA are listed in TABLE 3. Some isolates have short cells on both media, e.g. CBS701.82 (16.8-43.0µm), while others have long cells, e.g. D102-3 (401.4-478.8µm). Some isolates produce branches that are far apart, e.g. CBS119.12 (328.8-800.0µm), and other isolates have much shorter branch distance, e.g. CBS214.61 (46.5-92.4µm on PDA).

Four of the nine isolates statistically tested showed significant differences between hyphae either in cell length or branch distance (TABLE 4). Hyphae of CBS326.47 vary only in cell length not in branch distance. Hyphae of D85-3 varies in branch distance as well as in cell length on PDA, but only in cell length on WA. D194-1 has different branch distances of hyphae on PDA, whereas the hyphae of D227-4 have different cell lengths on WA.

Five of the isolates have a branching frequency significantly different from 1.0 on at least one of the two media employed (TABLE 5). Branching frequency is significantly lower than 1.0 on both media for D59-1 and D227-4, and in some of the hyphae on both media for CBS326.47, whereas it is significantly higher on WA for D94-1 and D194-1.

TABLE 4
Within isolate variation in cell length and distance between branches on PDA and WA were tested with a one factor analysis of variance. Each of three hyphae were measured ten cells and branches inwards from the tip. Significance of the F-value indicates, that the measurements on the three hyphae differ significantly. Significance levels 5%, 1% and 0.1% are indicated as *,** and *** respectively

	Cell length		Branch distance	
Isolate:	PDA	WA	PDA	WA
CBS326.47	5.75**	9.41***	0.83	0.94
D59-1	0.99	0.53	0.28	3.07
D85-3	5.26*	7.70**	6.42**	1.98
D93-1	0.51	0.45	0.57	2.31
D94-1	2.64	3.06	2.98	0.15
D102-3	0.02	0.61	0.30	1.84
D113-1	0.55	0.22	0.48	0.67
D194-1	2.22	1.20	5.91**	0.09
D227-4	1.28	7.91**	1.26	0.08

TABLE 5
Branching frequency. T-test for related samples of difference between cell length and branching distance for nine isolates. Each hypha is considered separately in isolates where hyphae differ significantly (see TABLE 4). Branching frequency differs from 1 when the t-test value is significant. Significance levels 5%, 1% and 0.1% are indicated as *,** and *** respectively.

Isolate	PDA	WA
CBS326.47	Hypha 1: 1.43 2: 4.54** 3: 5.47***	Hypha 1: 1.71 2: 6.19*** 3: 2.36*
D59-1	4.66***	2.16*
D85-3	Hypha 1: 1.52 2: 1.49 3: 0.97	Hypha 1: 0.65 2: 0.88 3: 1.71
D93-1	0.66	1.10
D94-1	0.04	3.72***
D102-3	0.50	0.96
D113-1	0.05	1.54
D194-1	Hypha 1: 0.15 2: 1.10 3: 0.23	2.08*
D227-4	2.70*	Hypha 1: 3.34** 2: 2.99* 3: 3.40**

The medium composition significantly influences the branch distance, cell length or both in six isolates (TABLE 6). When hyphal measurements differ significantly in a mycelium, media-induced variation can not be tested.

Information about the cell length range is compared with observations of five reference cultures (Fig.2). The data on cell length of the reference cultures is the range from the shortest to the longest cell of thirty cells measured.

Five mycelial branch characters are listed in TABLE 7. The branch structures in column A,B,C, and D were observed qualitatively. Observations were made on primary branches only.

TABLE 6

Variation in cell length and branch distance due to medium composition. T-test for the difference between theoretical means on PDA and WA of cell length and of distance between branches. T-values are given with significance levels indicated as *, **, and *** for 5%, 1% and 0.1% respectively.

Isolate	Longer cells on PDA than WA	Shorter cells on PDA than WA	More branches on PDA than WA	Less branches on PDA than WA
CBS326.47				2.81**
D59-1	1.57			2.26*
D94-1		3.22**		2.61*
D113-1		6.19***	4.00***	
D194-1		2.36*		
D227-4			4.96***	

Fig. 2

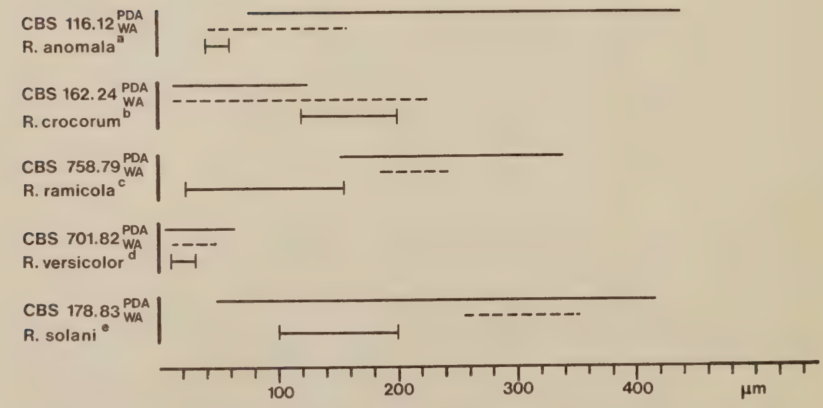
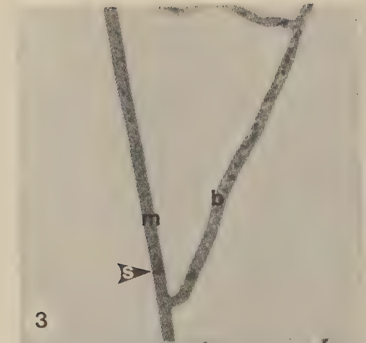


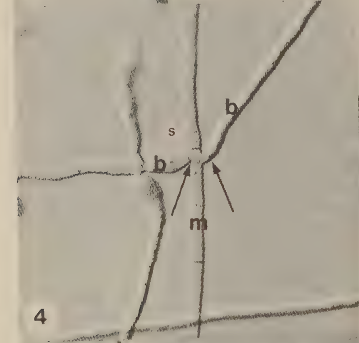
Fig.2. Cell length range of five reference cultures compared with literature information (bar between the vertical lines) regarding the anamorphs of the species to which the cultures are referred in the CBS catalogue. The literature used is, a: Burgeff (1936), b & e: Duggar (1915), c: Weber & Roberts (1951), d: Müller & Nüesch in: Gäumann et al. (1960). The observed range is taken from 30 measurements, 10 on each of three hyphae starting from the tip.

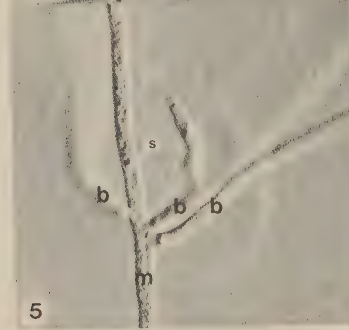
TABLE 7

Observations of branches in *Rhizoctonia*. Column A: Branching in relation to septa on the main hyphae. The branches originate either in the DISTAL part of the cell, or THROUGHOUT the length of the cell. Column B: Branching angle is ACUTE, RIGHT, or OBTUSE. Column C: Constricted at the point of origin, +, or not constricted, –. If the plus is in brackets, the constrictions are indistinct or rare, but observed at least once. Column D: Branches being of the SAME WIDTH, WIDER, or NARROWER than the main hyphae. Column E: Distance from the first septum of the branches to the point of origin measured along the curvature of the branch. The range is obtained from 30 measurements. All measurements in µm.

Isolate	A	B	C	D	E
CBS116.12	Throughout	Right	+	Same width	1.0–24.5
CBS119.12	Throughout	Right-acute	+	Wider	1.6–54.4
CBS116.20	Distal	Acute	(+)	Narrower	6.4–20.0
CBS162.24	Throughout	Right-(Acute)	+	Narrower	1.0–25.5
CBS155.38	Distal	(Right)-Acute	–	Same width	0.0–41.6
CBS326.47	Distal	Right-(Acute)	–	Narrower	1.6–5.6
CBS214.61	Throughout	Right-(Acute)	+	Wider	0.0–12.8
CBS758.79	Distal	Acute	+	Narrower	4.8–12.8
CBS476.82	Throughout	(Right)-Acute	(+)	Narrower	3.9–11.2
CBS701.82	Throughout	Obtuse-Acute	–	Narrower	0.0–24.0
CBS178.83	Distal	(Right)-Acute	+	Same width	3.2–30.4
D47-5	Distal	Right-(Acute)	+	Narrower	1.6–4.0
D47-6	Distal	Right-(Acute)	+	Narrower	1.6–7.2
D47-7	Distal	Right-(Acute)	+	Narrower	1.6–4.8
D59-1	Distal	Right	+	Narrower	1.6–6.4
D85-3	Distal	Acute	+	Same width	4.8–21.3
D93-1	Throughout	Right-Acute	+	Narrower	2.4–6.4
D94-1	Distal	(Right)-Acute	(+)	Narrower	2.4–5.6
D102-3	Distal	Acute	+	Same width	8.0–19.2
D113-1	Throughout	Acute	+	Same width	2.4–16.0
D131-1	Distal	Right-Acute	+	Narrower	2.4–16.8
D132-2	Throughout	Right	+	Narrower	0.8–8.0
D145-1	Distal	(Right)-Acute	+	Narrower	1.6–6.4
D145-4	Distal	Right-(Acute)	+	Narrower	2.4–6.4
D145-13	Distal	Right-(Acute)	(+)	Narrower	2.4–6.4
D186-1	Distal	(Right)-Acute	(+)	Narrower	1.6–6.4
D188-5	Distal	(Right)-Acute	(+)	Same width	4.0–12.8
D194-1	Distal	Right-(Acute)	(+)	Narrower	1.6–6.4
D197-3	Throughout	Right-Acute	(+)	Narrower	1.6–6.4
D227-4	Throughout	Right	+	Same width	12.8–36.0







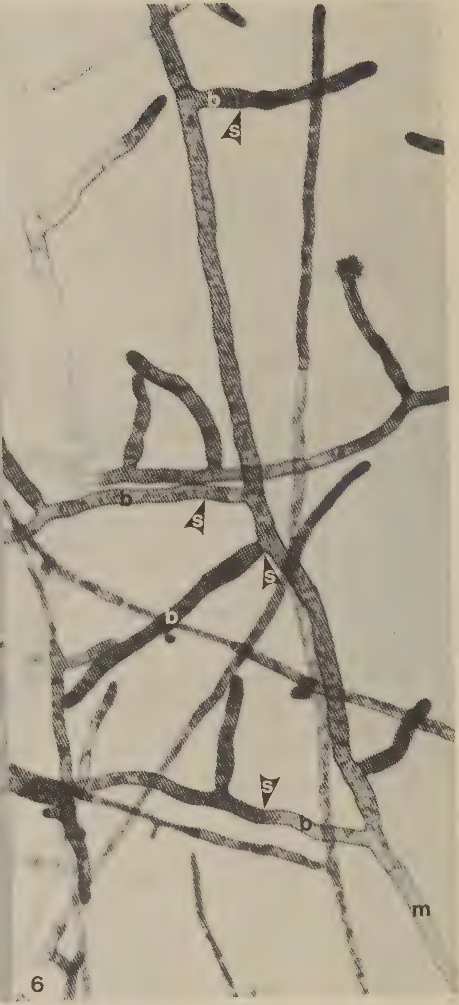
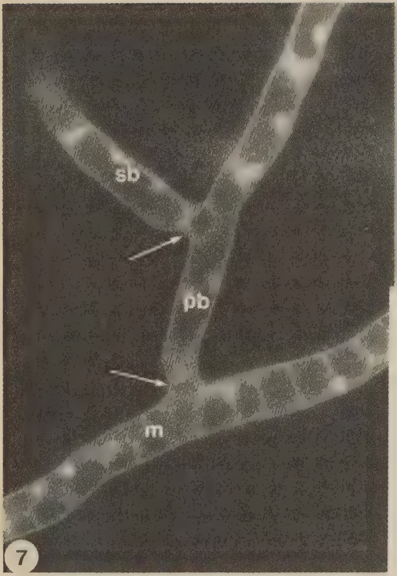


Fig.3. Isolate D 188-5. One primary branch (b) immediately before a septum (s). The proximal part of the branch is perpendicular to the main hypha (m), but after a few µm it bends into a 45° angle. Grown on 1% PDA. Stained with ABB and viewed in LM. 329x. **Fig.4.** Isolate D 197-3. Two primary branches (b) originating immediately before a septum (s) on the main hypha (m). The first septa (arrows) are formed close to the point of origin. Grown on WA. IC. 329x. **Fig.5.** Isolate D 94-1. Three primary branches (b) originating immediately before a septum (s) on the main hypha (m). Grown on WA. IC. 493x. **Fig.6.** Isolate 227-4. Right-angled branching. The general direction of growth of most of the primary branches (b) away from the main hypha (m) is at right angles. The distance of the first septum (s) in the branches from the point of insertion varies considerably. Grown on 1% PDA. Stained with ABB and viewed in LM. 329x.



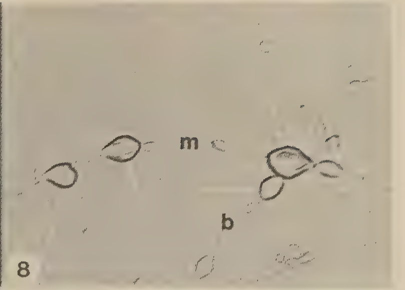


Fig.7. Isolate CBS 116.12. Constrictions (arrows) at the insertion of the primary branch (pb) on the main hypha and in this isolate also of the secondary branch (sb) at the point of origin. Grown on WA. Stained with acridine orange and viewed in FM. 657x. **Fig.8.** Isolate CBS 116.12. Inflated cells (arrows) of the main hypha (m) and branch (b) formed in an old mycelium. Grown on 1% PDA. IC. 131x.

19 isolates only formed branches at the distal end of the main hyphal cells (TABLE 7-column A). Mostly one branch is present (Fig.3), but the number of branches may be two (Fig.4) or three (Fig.5). 11 isolates branched throughout the length of the main hyphal cells. Eight of these CBS116.12, CBS119.12, CBS162.24, CBS214.61, CBS476.82, CBS701.82, D132-2, and D227-4 varied on both media with respect to branch position, whereas the isolates, D93-1, D113-1, and D197-3, branched throughout the length of the cells on WA, having a distal position for the branches on PDA.

Observation of branching angle is listed in TABLE 7-column B. The term "right-angled growth" was used to describe branches with a general direction of growth perpendicular to the main hypha (Fig.6). In some isolates the branches grow at right angles for less than 20µm, and then bend into an acute angle (Fig.3). This is called acute angled growth in this study.

Most of the isolates show a constriction at the branch insertions (TABLE 7-column C, Fig.7). The constriction may be inconspicuous, shown as a (+), and often the secondary branches are not constricted while the primary branches are.

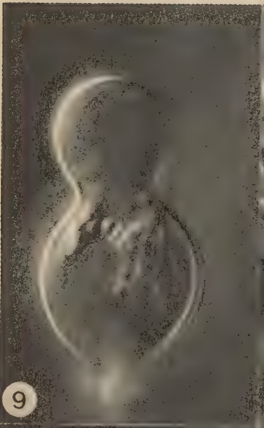
The branches were narrower than the main hyphae in most isolates, but two isolates had wider branches, and eight isolates had branches of the same width as the main hyphae (TABLE 7-column D).

The distance between branching point and the first septum

TABLE 8
Shape and size of monilioid cells on 1% PDA (the MC's of D227-4 on CM2). The abbreviations used for the shapes are: Dol(iform), Cyl(indric), Subg(lobose), Irre(gular), Obo(vate), Cla(vate), and Glo(bose). The size of the monilioid cells is given as minimum-(mean)-maximum of length and width respectively. All measurements in µm.

Isolate	Shape	Length	Width
CBS116.12	Dol-Cyl	32.0-(42.0)-52.0	12.0-(17.6)-23.2
CBS758.79	Dol	16.0-(20.4)-24.8	8.0-(10.8)-13.6
CBS178.83	Dol	18.4-(33.2)-48.0	8.8-(12.0)-15.2
D47-5	Subg	8.8-(14.0)-19.2	8.0-(12.4)-16.8
D47-6	Subg	9.6-(14.0)-18.4	8.0-(12.0)-16.0
D47-7	Subg	8.8-(13.6)-18.4	8.8-(12.4)-16.0
D59-1	Subg	9.6-(14.0)-18.4	8.8-(13.2)-17.6
D85-3	Dol-Cyl	13.6-(20.4)-27.2	8.0-(10.4)-12.8
D93-1	Subg-Dol	11.2-(17.2)-23.2	8.8-(14.4)-20.0
D94-1	Irre	9.6-(16.4)-23.2	8.0-(13.2)-18.4
D102-3	Irre	20.8-(34.4)-48.0	8.8-(13.6)-18.4
D113-1	Subg	11.2-(14.8)-18.4	7.2-(11.6)-16.0
D131-1	Dol-Cla	9.6-(16.8)-24.0	4.0- (6.8) -9.6
D132-2	Dol-Cyl	14.4-(24.0)-33.6	8.8-(13.6)-18.4
D145-1	Glo	14.4-(18.8)-23.2	12.8-(16.4)-20.0
D145-4	Subg-Dol	9.6-(12.4)-15.2	8.8-(10.4)-12.0
D145-13	Dol-Obo	9.6-(14.0)-18.4	7.2-(10.0)-12.8
D186-1	Irre	16.8-(27.6)-38.4	8.0-(13.6)-19.2
D188-5	Dol-Cyl	16.0-(25.2)-34.4	8.0-(10.8)-13.6
D194-1	Dol	12.0-(18.0)-24.0	9.6-(13.6)-17.6
D197-3	Irre	12.0-(22.0)-32.0	6.4-(12.2)-16.0
D227-4	Dol-Irre	16.8-(24.4)-32.0	8.0-(10.8)-13.6

Figs.9-18. Monilioid cells. **Fig.9.** Chain formation by budding in D47-5. Each member of the chain is fully developed before they can give rise to a new cell by the formation of a bud which eventually will be separated from the mother cell by a wall. Grown on CM2. Viewed with IC-optics. 1800x.**Fig.10.** Monilioid cell formation by simultaneous swelling of several cells (chlamydospore-type) in D131-1. Grown on CM2. IC. 900x. **Fig.11.** Branching of monilioid cell chains in CBS758.79. The cells in this isolate are doliform (barrel-shaped). Grown on 1%PDA. IC. 576x. **Fig.12.** A short, unbranched chain of globose to subglobose monilioid cells in D197-3 when grown on CM2. IC. 576x. **Fig.13.** Conspicuous pore plugs in the cell wall between two monilioid cells in D132-2. These cells appear empty, and might be sealed off because of that. Grown on 1%PDA. IC. 900x. **Fig.14.** Branched chains of globose monilioid cells in D59-2. Stained with acridine orange and viewed in epifluorescense microscope. Grown on CM2. 225x. **Fig.15.** Cylindric monilioid cells in D188-5. These cells occur in branched chains together with irregular and doliform cells. Grown on CM2. IC. 576x. **Fig.16.** Obovate monilioid cells in D145-4. Grown on CM2. IC. 576x. **Fig.17.** Branches of clavate monilioid cells intermixed with doliform cells in D131-1 when grown on 1%PDA. IC. 576x. **Fig.18.** Chains of irregular monilioid cells of D197-3 on 1%PDA. IC. 576x.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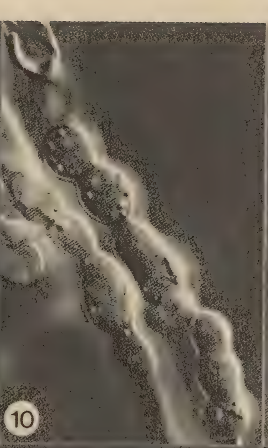
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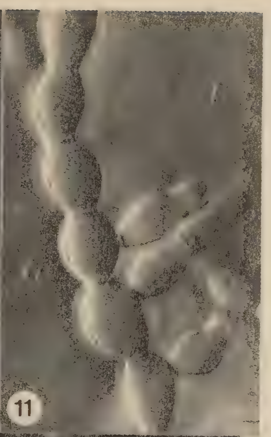
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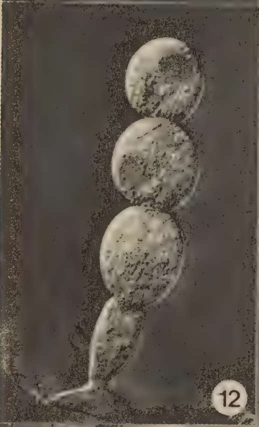
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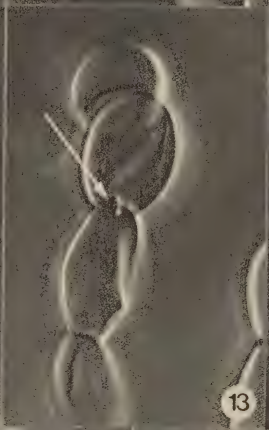
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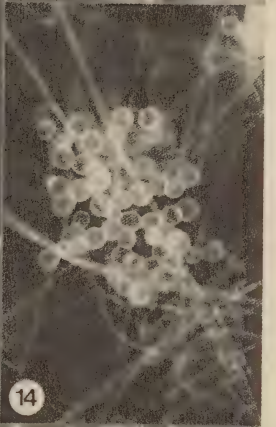
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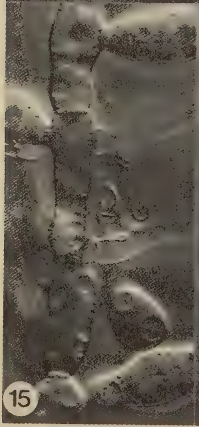
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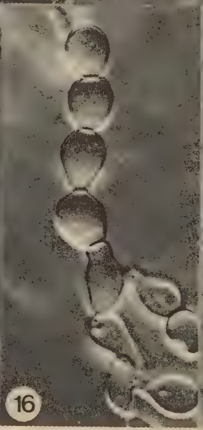
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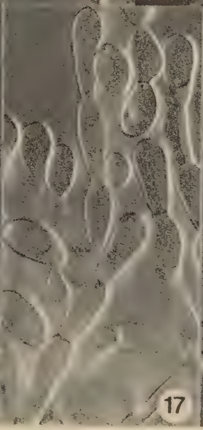
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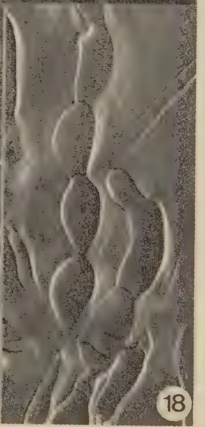
18

Fig. 19

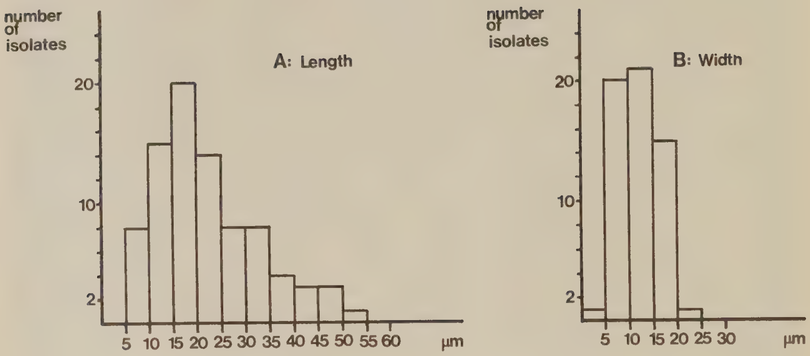

Fig.19. A compilation of measurements of monilioid cells of cultures grown on 1%PDA. The measurements of A:length and B:width are split in 5µm intervals and the isolates are registered in all intervals which their size range covers.

in the branch varies (TABLE 7-column E). However, some isolates always make a septum within the first 0-15µm in a branch, e.g. D197-3 (Fig.4). The position of the first septum may vary within a wide range, e.g. D227-4 (Fig.6).

Monilioid cells arise both by budding (Fig.9), and by septation and inflation of branch sections (Fig.10). They form branched chains (Fig.11), although short, unbranched chains do occur in some isolates (Fig.12). The cytoplasm of each monilioid cell is often isolated by a conspicuous plug in the septa (Fig.13).

The size, shape and number of monilioid cells varies considerably in the isolates studied (TABLE 8). For comparison, only monilioid cells produced on 1% PDA are listed, except for D227-4, which only produced monilioid cells on CM2.

from globose (Fig.14) to cylindric (Fig.15), the latter not differing much from the ordinary hyphal cells. Various other shapes are represented: subglobose, obovate (Fig.16), doliform (Fig.11), clavate (Fig.17), or irregular (Fig.18).

The variation in monilioid cell size seems to be rather large, but a compilation of the size range of the isolates shows, that the isolates overlap in measurements of length as well as in width (Fig.19).

The composition of the medium influences both the formation of monilioid cells, and their size and shape. Some isolates do not produce monilioid cells on CM2, e.g. CBS116.12, D93-1, D145-1, and D194-1, while they do on 1% and 2% PDA. The shape and size of monilioid cells and the chain length varies considerably in isolate D197-3. On 1% PDA the cells are irregularly elongated, 12.0-32.0µm by 6.4-16.0µm (Fig.18), while they are globose to subglobose, 16.0-44.0µm by 12.0-44.0µm (Fig.12) on CM2. On CM2 the unbranched chains consists of up to five cells, while the branched chains on 1% PDA can reach a length of 20 cells.

Isolates CBS119.12, CBS116.20, CBS162.24, CBS155.38, CBS326.47, CBS214.61, CBS476.82, and CBS701.82, did not produce monilioid cells on any of the media used.

DISCUSSION

Hyphal width. Several original descriptions of *Rhizoctonia* species include information on hyphal width; 6µm in average, *Rhizoctonia alpina* (Castellani 1935), (5)-6-14µm, *R. solani* (Parmeter & Whitney 1970), and "up to 17µm", *Thanatephorus orchidicola* (Warcup & Talbot 1966). Some species were noted to have very narrow ranges in hyphal diameter, for example *R. neottiae* (3-5µm (Wolff 1926)), while other species are noted as having a large variation in width depending on the medium used, such as *R. anomala*, which swells on some media (Fig.8) (Burgeff 1936).

Most of the isolates studied here overlap in the range 4-5µm in main hyphal diameter and cannot be separated by this character. CBS155.38 is the only isolate with characteristic narrow hyphae, 1.6-3.2µm. The isolates with conspicuously wide hyphae show a similar pattern as *Rhizoctonia solani*, which is noted to possess main hyphae generally not less than 5µm in width (Parmeter & Whitney 1970).

Two isolates, CBS326.47 and CBS178.83, fit the original description of the species with respect to hyphal width, whereas isolates CBS758.79 and CBS476.82 represent only a minor portion of the range recorded for the species (Fig. 1). Three isolates, CBS116.12, CBS119.12 and CBS701.82, cover a much larger or different range. The width of the main hyphae varies considerably. If the origin of the isolates as subcultures of types is correct, either the descriptions are imprecise or the cultures have changed with time. Either case makes the usefulness of the character in the delimitation of species questionable.

Cell length and branching frequency. Several different methods have been employed to describe growth of a mycelium. Cell length measurements have been used as a diagnostic character to delimitate species in *Rhizoctonia* (Castellani 1935, Burgeff 1936, Weber & Roberts 1951). Recently the mean distance between branches, "Internode Length Unit" (ILU), was introduced (Armentrout et al. 1986). The results presented here do not support the conclusions of Armentrout et al. (1986), nor does their approach seem applicable to other species of *Rhizoctonia*. In some isolates, CBS326.47, D85-3, D194-1 and D227-4, there is a significant difference between different main hyphae in the same mycelium with regard to branch distance or cell length or both.

Rhizoctonia solani is rather easy to identify on nuclear, sclerotial and hyphal characters (Parmeter & Whitney 1970), and isolates CBS178.83 and D227-4 belong to this species. The mean branch distance is very different in these two isolates and varies with the media (TABLE 3). Hence, ILU cannot be considered to be consistent within *Rhizoctonia solani*.

Different media affect cell length as well as branch distance, but the response varies according to the isolate. These differences in response could be due to different growth strategies. When transferred to poor medium, some isolates may explore new areas quickly by producing longer cells or more pronounced branching. This response is known in various genera of the Agaricaceae (Erik Bille Hansen pers. comm.). Other isolates may slow down growth, resulting in fewer branches or shorter cells.

To perform a direct comparison with the measurements given in the literature one has to test the growth on all media used in the descriptions of the type species.

The cell length range in four out of five reference cultures match poorly with the type descriptions (Fig.2). The cell length in the original description was generally shorter than could be observed in this study. There could be three explanations. 1: The type descriptions were based on observations on media, in which the fungi produced short cells. 2: The reference cultures used in this study were not correctly identified. 3: The cultures could have changed with regard to cell length during the years in storage.

Ad 1: The longest cell described in the literature was 548µm noted for *Rhizoctonia gossypii* (Forsteneichner 1931). The longest cell observed in this study on PDA is found in D102-3 and measured 711µm. Since PDA has been used by several authors (Saksena & Vaartaja 1960, Husain & McKeen 1963, Tu & Kimbrough 1975), it is not likely that medium composition can account for the much shorter cells described in the literature.

Ad 2: Due to the limited descriptions some of the isolates might be incorrectly identified, but three of the isolates shown in Fig.2, CBS116.12, CBS758.79, and CBS701.82, originate from the author of the species in question. For these three strains misidentification seems to be unlikely.

Ad 3: It was not possible to compare the living reference cultures with the permanently preserved type specimens. Judging from requests for the type specimens it seems that very few species are represented by a proper type specimen.

In conclusion, measurements of cell length or branching distance cannot be used in the delimitation of species or groups within *Rhizoctonia*.

Branch characters. Duggar (1915) characterized the mycelial branches of *Rhizoctonia* by the angle at which branches arise, by the presence of a constriction at the point of origin, and by the distance of the first septum of the branches from the point of origin. These characters have been used extensively in descriptions of *Rhizoctonia* species (Castellani 1935, Weber & Roberts 1951, McKeen 1959, Saksena & Vaartaja 1960, Yamamoto 1962, Husain & McKeen 1963, van der Hoeven in: Boerema & Verhoeven 1977). The width of the mycelial branches has also been used (Wolff 1926).

11 isolates out of 30 branch throughout the length of the main hyphal cells (TABLE 7-column A). *Rhizoctonia* s.l. shows no fixed spatial relationship between septation and branching.

The angle of branching is not usable in the delimitation of species of *Rhizoctonia* considering the variation observed within each mycelium (TABLE 7-column B). Furthermore, this character is subjected to differing interpretations; Castellani (1935) described branching in *R. callae* as acute, while Saksena & Vaartaja (1961), who examined one of Castellanis' subcultures noted branching nearly at right angles.

Constriction of the branch at the point of insertion has been noted by several authors of *Rhizoctonia* species (McKeen 1959, Saksena & Vaartaja 1960, Yamamoto 1962, Husain & McKeen 1963, van der Hoeven in: Boerema & Verhoeven 1977). Most of the isolates in this study show a constriction of the branches (TABLE 7-column C), but it is often found in just a few of the branches and is often inconspicuous. This character should not be used in the delimitation of species of *Rhizoctonia* s.l.

Branches in species of *Rhizoctonia* have been observed to be either narrower than the main hypha (Wolff 1926) or wider than the main hyphae (van der Hoeven in: Boerema & Verhoeven 1977). In the isolates studied here, branches are mostly narrower than the main hyphae (TABLE 7-column D) on both media used.

Some isolates make a septum in the proximal part of the branch. This is associated with a migration of the nuclei from the main hypha into the branch primordium followed by a mitotic division (Flentje et al. 1963). The formation of a septum in assotiation with branching is probably common in septate mycelia, and it seems too variable to use in the delimitation of groups or species within *Rhizoctonia* s.l.

Monilioid cells. The production of monilioid cells is generally considered to refer a culture to *Rhizoctonia* (Bernard 1909, Burgeff 1936, Castellani 1935, Duggar 1915, Saksena & Vaartaja 1960), and variations in these cells are often used to distinguish among species. The shape and size as well as their aggregation into sclerotia (Tu & Kimbrough 1975) have been used to define species.

The observations presented here show that the shape and size of monilioid cells, if produced, are media-dependent. Furthermore, the shape designations (TABLE 8) refers to the most commonly observed shape, not to the basal cells or irregular cells in the process of swelling or budding. Irregular monilioid cells are probably always immature and therefore not of any taxonomic value.

The taxonomic problems of using monilioid cells in defining a species can be illustrated by *Rhizoctonia repens* Bernard (1909). Available type material consists of a protologue with data, which can be observed in almost all rhizoctonias, and a drawing of what appears to be immature monilioid cells. It will not be possible to refer an isolate to this species with any degree of certainty.

From the results obtained here it is clear, that it is necessary to employ the same medium for comparison of cultures with type descriptions. In spite of all efforts to identify a culture, one will still end up with a group of possible species conforming to the International Code of Botanical Nomenclature (Voss 1983), but inseparable simply because the observations described in the protologues were made on different media.

In this paper the problems of most traditional morphological characters used to define *Rhizoctonia* species have been pointed out. Parmeter (1965) reached the "inescapable conclusion", that "a mycelium cannot be placed in any described species of Mycelia Sterilia with any assurance that it is actually the same fungus as was originally described". On the basis of this study I agree as far as *Rhizoctonia* is concerned. The form genus has to be brought in line with the nomenclatorial rules and then revised taxonomically. The recently established genera of Moore (1987) may be a relevant tool to establish well defined species based on anamorph identification.

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A NEW SPECIES OF MELANOMPHALIA (CREPIDOTACEAE)

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Abstract

A new species of *Melanomphalia, M. globulifera,* is described from Texas and Mississippi. This species is remarkable because of its small globose spores reminiscent of *Crepidotus* sect. *Echinospori.* This feature shows that *Melanomphalia* is correctly classified in the family Crepidotaceae.

The genus *Melanomphalia* Christiansen, based on *M. nigrescens* Christiansen, was studied and monographed by Singer (1955, 1971). The genus differs from *Crepidotus* by its omphalioid, even sometimes mycenoid or collybioid habit and constant central stipe. Species of *Melanomphalia* known thus far, have spores that are slightly to strongly elongated. Collections from Texas and Mississippi introduce a new species, *M. globulifera,* with small, globose spores. It is the first *Melanomphalia* with nearly perfectly globose spores. While spore print color and spore shape and size are quite variable in *Melanomphalia,* the finely echinate ornamentation of its spores is like that found in *Crepidotus* sect. *Echinospori* Pilát. The spores of *M.*

globulifera closely resemble the spores of *Crepidotus harperi* Sing., *C. quitensis* Pat., *C. conchatus* Hesl. & Smith and *C. tahquamenonensis* Hesl. and Smith.

In the following description, color comparisons were made using Kornerup and Wanscher (1978) and Munsell (1976).

Melanomphalia globulifera Singer, Ovrebo and Lewis, sp. nov.
Figs. 1-4

Pileo albido vel pallide alutaceo-grisello, frequanter dein rubrobrunneo-maculato vel lineato, hygrophano, in siccis dilute brunneolo vel subalbido, plerumque humido sed opaco, transparenter striato, glabriusculo, umbilico profundo instructo, 8-25 mm lato. Lamellis roseolo-alutaceis subgrisellis, paullum obscurioribus pileo, fractu immutabilibus sed sparse rubrobrunneo maculatis aetate, confertis, ± 2 mm latis, decurrentibus. Sporis in cumulo roseolo-brunneis. Stipite albo vel albido-alutaceo glabro, sericello, solido, aequali vel basin versus attenuato, 10-23 x 2-4.5 mm. Carne superficiei concolori vel alba, immutabili, haud tenaci; odore nullo; sapore lento raphanaceo. Sporis 4.5-6 x 4.3-5.5 µm, globulosis, intra perisporium spinis tenuiter subcyndraceis ± 0.5 µm longis, brunneis (et sporis ex eis punctatis) tectis, inamyloideis. Basidiis 16-21(-25) x 6-7 µm, tetrasporis. Cystidiis nullis. Cheilocystidiis (35-)55-90 x 4.5-8(-9.2) µm, subcylindraceis, frequenter apice subcapitatis aut, raro, constrictis hyalinis, pariete tenui aut firma, immo crassiuscula sub apicem (usque ad 0.7 µm) instructis. Hyphis fibulis praeditis, in hymenophoro regulari hyalinis. Epicute pilei et stipitis ex hyphis hyalinis, terminalibus saepe recurvatis et dermatocysitidiis instructis, dermatocystidiis quam cheilocystidia nonnihil crassioribus et frequenter subclavatis. Gregatim vel subaespitose ad lignum putridum. Typus in Mississippi a C. L. Ovrebo 2682 collectus (F).

Carpophore stature omphalioid; pileus 8-25 mm wide, deeply umbilicate, circular or occasionally at first spathulate and then orbicular, the edge downcurved; surface moist, dull, translucent-striate 7 mm in from edge, whitish to very faint buff-gray (5B2-3), often developing dull reddish brown spots or streaks in age, not discoloring where bruised, hygrophanous, drying light buff where moisture leaves; context 0.5-1 mm thick, concolorous with surface; odor absent, taste very slowly raphinoid.

Lamellae ± 2 mm wide, decurrent, grayish pinkish buff (5B3) and slightly darker than the pileus, developing scattered dull reddish brown patches in age but not discoloring where bruised, close; edges very finely fimbriate under 10X; lamellulae numerous but not in distinct tiers.

Stipe 10-23 mm long, 2-4.5 mm thick, equal or slightly tapered to the base, central but occasionally somewhat eccentric at first, glabrous, silky looking, whitish buff, not discoloring; context solid or hollow, concolorous with the surface.

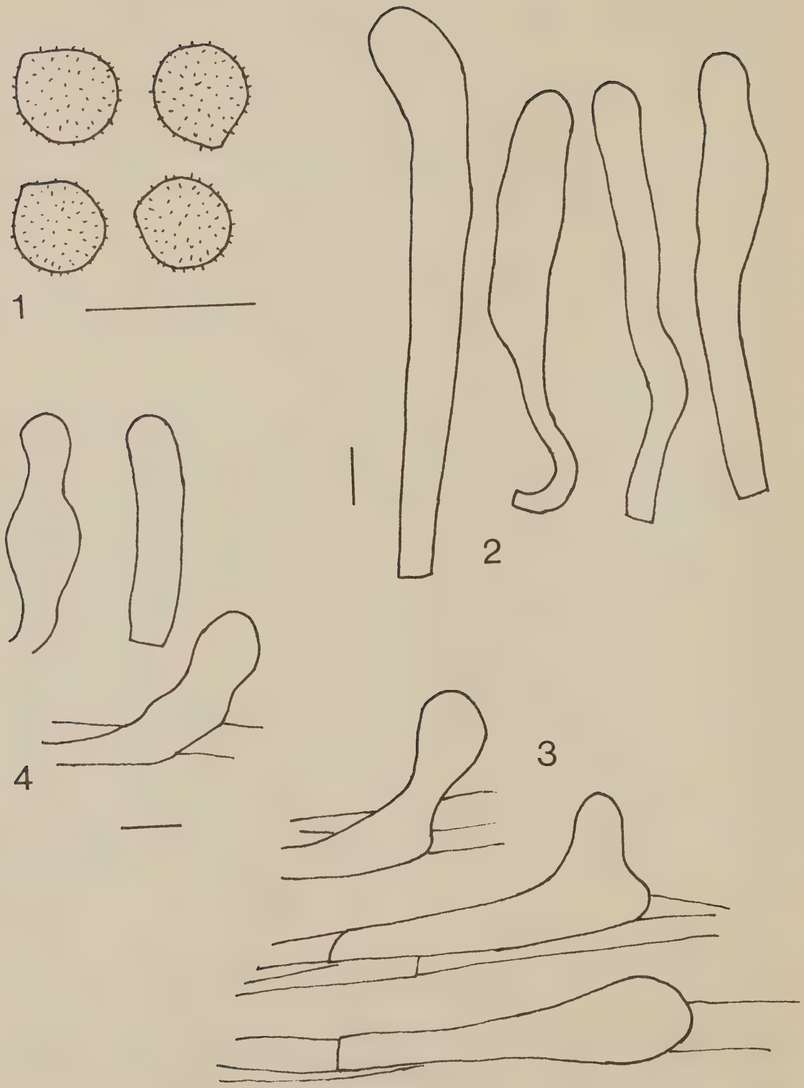
Spore deposit pinkish brown (5YR - 7.5YR 5/6).

Chemical color reactions: no reaction on fresh carpophores with 2.5% KOH.

Spores 4.5-6 x 4.3-5.5 μm, almost always globose in profile and face view, distinctly finely echinate with spines ± 0.5 μm long, pinkish melleous in KOH, inamyloid, appearing acyanophilic. Basidia 16-21(-25) x 6.0-7.0μm, 4-sterigmate, clavate, hyaline. Cheilocystidia (35-)55-90 x 4.5-8.0(-9.2) μm, cylindric to cylindric-flexuous, often subcapitate, often collapsed, smooth, wall thin or slightly thickened (up to 0.7 μm) beneath the apex, hyaline. Pleurocystidia absent. Hyphae of pileus surface 4.8-8.21 μm wide, a cutis with moderately abundant cystidiform end-cells, cylindric to subclavate, appressed or recurved, up to 11.5 μm wide, all cells smooth, thin-walled, hyaline. Hyphae of pileus trama up to 11.5 μm wide, cylindric to slightly inflated, hyaline. Hyphae of stipe surface 4.0-5.8 μm wide, with abundant caulocystidia, 31-70 x 5.8-10.4 μm, scattered or often forming a continuous layer, cylindric to clavate, smooth, thin-walled, hyaline. Hyphae of stipe trama up to 15 μm wide, cylindric to slightly inflated, hyaline. Gloeovessels common throughout carpophores, pale yellow. Clamp connections present.

Gregarious, sometimes subcespitose, on dead hardwood and woody detritus.

Collections studied: Mississippi: Perry Co.: Black Creek area, 22 July 1988, C. L. Ovrebo 2682 (holotype, F). Texas: Orange Co.: Vidor, Our Lady of Lourdes Catholic Church grounds, 12 July 1988, D. P. Lewis 4140 (F).



Figs. 1-4. *Melanomphalia globulifera* (holotype). 1. Basidiospores. 2. Cheilocystidia. 3. Cystidiform end-cells of pileus. 4. Caulocystidia. Scale line = 10 μm.

Like many species of *Melanomphalia* and *Crepidotus* sect. *Echinospori,* the spores appear to be covered by a hyaline perisporium which is sometimes slightly perforated or uplifted by the spinules arising from a brownish episporium. In light microscopy this has been described and illustrated (Singer, 1986, pl. 14, figs. 2&3) as type XI spore ornamentation, but does not usually show up as such in species of *Crepidotus* when studied with the electron microscope (cfr. Clémençon, 1977).

The exceptionally eccentric young specimens were occasionally observed and seem to result from growing conditions (subcespitose material), through pressure whereby the pileal development is inhibited so that it becomes subspathulate instead of orbicular in circumference. Tendency toward the pleurotoid habit in most agarics develops mainly in mature specimens and it is the young specimens which may be centrally stipitate. In *Crepidotus nyssicola* (Murr.) Sing. with similar but larger spores than *M. globulifera,* a stipe is eccentric particularly in the mature fruiting bodies and in *C. stipitatus* Kauffman the stipe is always eccentric to almost lateral. In both these Crepidoti, the stipe is up to half as long as the pileus diameter. It is much shorter than in our species. Thus, although confirming the affinity with *Crepidotus,* our new species is strictly omphalioid and has no close relatives in *Crepidotus.* It has, however, a closely related species, *M. leucocephala* Singer from Costa Rica which differs mainly by a convex pileus and often more elongated spores.

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COLUMNOCYSTIS, A SYNONYM OF *VELUTICEPS*

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Abstract

Columnocystis Pouz. is considered as a synonym of *Veluticeps* (Cooke) Pat. All species described in *Veluticeps* and *Hymenochaete* subg. *Veluticeps* are listed and supplied with full references. The following new combinations in *Veluticeps* are proposed: *V. abietina* (Pers.: Fr.) Hjortst. & Tellería, *V. africana* (Boid. et al.) Hjortst. & Tellería, *V. ambigua* (Peck) Hjortst. & Tellería and *V. pimeriensis* (Gilb.) Hjortst. & Tellería. The new genus *Erythromyces* Hjortst. & Ryv. is described to accommodate *Hymenochaete crocicreas* Berk. & Br. and the new combination *Erythromyces crocicreas* (Berk. & Br.) Hjortst. & Ryv. is made. A lectotype of *Hymenochaete veluticeps* Berk. & Curt. is designated.

VELUTICEPS (Cooke) Pat. in Bull. Soc. Mycol. Fr. 10: 78 (1894)

≡*Hymenochaete* Lév. subg. *Veluticeps* Cooke in Grevillea 8: 148 (1880)
=*Columnocystis* Pouz. in Česká Mykol. 13: 17 (1959)
Generic type: *Hymenochaete veluticeps* Berk. & Curt. in Journ. Linn. Soc. Bot. 10: 333 (1868)
Generitype specimen. Lectotype, designated here: Cuba, Wright n.º 236 (K)

BASIDIOME resupinate to effused-reflexed or almost pileate, often stratified and with a distinct pale to brown, more rarely hyaline subiculum. HYMENOPHORE pilose by protruding skeletocystidia, single or in fascicles. HYPHAL SYSTEM dimitic; hyphae thin- or thick-walled, hyaline to pale yellowish brown, with or without clamp-connexions. SKELETOCYSTIDIA abundant, either single or more commonly in fascicles, thick-walled, apically obtuse and generally encrusted, pale to dark reddish-brown. BASIDIA narrowly clavate, with four sterigmata and a basal clamp-connexion. SPORES ellipsoid to cylindrical, often somewhat fusiform, rather large (10-25 μm long), thin-walled, smooth, hyaline, inamyloid, indextrinoid and acyanophilous.

All the species of *Veluticeps* as defined above have similar skeletocystidia, although in some species they form fascicles which, when they project above the basidial layer are somewhat reminiscent of the "hyphal pegs" in *Epithele* (Pat.) Pat. In the latter, however, the pegs are composed of hyphae alone and not cystidia. Also the basidia of *Veluticeps,* as well as the size and morphology of spores, indicate a close relationship to *Columnocystis*. The spores in both genera are rather large, often between 10-15 µm, occasionally up to 25 µm long. Important is also that both *V. berkeleyi* and all species which were placed in *Columnocystis* are reported to cause brown rots (GILBERTSON, 1981). JÜLICH (1981) placed these two genera in different families (and orders), Chaetodermataceae *(Columnocystis)* and Duportellaceae *(Veluticeps)*.

Species accepted:

Veluticeps berkeleyi (Cooke) Pat. in Bull. Soc. Mycol. Fr. 10: 77 (1894) ≡ *Hymenochaete veluticeps* Berk. & Curt. in Journ. Linn. Soc. Bot. 10: 333 (1868) ≡ *Hymenochaete* [subg. *Veluticeps*] *berkeleyi* Cooke in Grevillea 8: 149 (1880)

Veluticeps abietina (Pers.: Fr.) Hjortst. & Tellería, **comb. nov.**
Basionym: *Thelephora abietina* Pers.: Fr. Syst. Mycol. 1: 442 (1821)

Veluticeps africana (Boid. et al.) Hjortst. & Tellería, **comb. nov.**
Basionym: *Columnocystis africana* Boid., Lanq. & Gilles in Cryptog. Mycol. 4: 129 (1983)

Veluticeps ambigua (Peck) Hjortst. & Tellería, **comb. nov.**
Basionym: *Stereum ambiguum* Peck in N. Y. St. Mus. Ann. Rep. 47: 145 (1894)

Veluticeps heimii Malen. in Bull. trimest. Soc. Mycol. Fr. 55: 42 (1939)

Veluticeps pimeriensis (Gilb.) Hjortst. & Tellería, **comb. nov.**
Basionym: *Columnocystis pimeriensis* Gilb., Fungi that decay ponderose pine. Univ. Arizona Press, Tucson: 87 (1974)

Veluticeps pini Pat. in Bull. trimest. Soc. Mycol. Fr. 23: 72 (1907)

Note: In the original description PATOUILLARD (loc. cit.) indicated that "Especé analogue à *V. berkeleyi*" and according to GILBERTSON (1968), who studied the lectotype, this species is very similar to *V. berkeleyi*.

Veluticeps setosa G. H. Cunn. in N. Z. Dept. Sci. Industr. Res. Bull. 145: 332 (1963), with English description and indication of holotype on p. 301; non *Hymenochaete* [subg. *Veluticeps*] *setosa* Berk. & Curt. in Cooke, Grevillea 8: 149 (1880) ≡ *Hymenochaete setosa* Berk. & Curt. in Grevillea 1: 165 (1873)

Note: According to the label of the holotype of *H. setosa* Berk. & Curt.this is a species of *Trichosporum* Fr. and BURT (1918) states that it is a hyphomycete.

Veluticeps tabacina (Cooke) Burt in Ann. Mo. Bot. Gard. 6: 261 (1919)
≡*Aleurodiscus tabacinus* Cooke in Grevillea 14: 11 (1885)

Excluded species:

Hymenochaete [subg. *Veluticeps*] *archeri* (Berk.) Cooke in Grevillea 8: 149 (1880) ≡*Stereum archeri* Berk. in Hooker's Bot. Antarct. Voy. Part III, Fl. Tasm. 2: 259 (1859) = **Xylobolus illudens** (Berk.) Boid. in Rev. Mycol. 23: 341 (1958)

Stereum carpaticum Pilát in Hedwigia 70: 78 (1930) ≡ *Columnocystis carpatica* (Pilát) Pouz. in Česká Mykol. 13: 17 (1959)

Note: This species is presumably the same as *Veluticeps ambigua.*

Hymenochaete [subg. *Veluticeps*] *crocicreas* Berk. & Br. in Cooke, Grevillea 8: 149 (1880) ≡ *Hymenochaete crocicreas* Berk. & Br. in Journ. Linn. Soc. Bot. 14: 68 (1873)

Note: This species does not belong in *Hymenochaete* Lév. primarily due to the lack of setae and the presence of clamp-connexions. It is separated from *Veluticeps* by its monomitic hyphal system, a different cystidial type and the production of a white pocket rot. The following new genus is proposed:

ERYTHROMYCES Hjortst. & Ryv., **gen. nov.**

Basidioma resupinatum, adnatum, quasi 1-2 mm crassum. Hymenophorum leve vel per cystidiis projectis pilosum. Color plus minus rufus. Systema hyphale monomiticum; hyphae tenuitunicatae vel crassitunicatae, moderate latae, interdum valde incrustatae, fibulatae. Cystidia numerosa, crassitunicata, testacea vel rubella, plerumque 100 µm longa. Basidia plus minus pedunculata, tenuitunicata, 4 sterigmatibus. Sporae ellipsoideae vel anguste ellipsoideae, mediocres, in typo 6-8 × 2.8-3.2 µm, tenuitunicatae, leves neque amyloides, neque dextrinoides.

Generic typus: *Hymenochaete crocicreas* Berk. & Br.
Generitype specimen: Sri Lanka, on decayed wood, Thwaites n.° 658, holotypus (K)

BASIDIOME resupinate, adnate, about 1-2 mm thick. HYMENOPHORE pilose by protruding cystidia, cinnamom brown to fawn-coloured. HYPHAL SYSTEM monomitic; hyphae thin to moderately thick-walled or thick-walled, with clamp-connexions. CYSTIDIA numerous, thick-walled, subulate, yellowish brown to reddish, ordinarily 100 µm long. BASIDIA clavate, more or less pedunculate, with four sterigmata and a basal clamp-connexion. SPORES ellipsoid to narrowly ellipsoid, thin-walled, smooth inamyloid, indextrinoid.
The noteworthy unique combination of a reddish and strongly pilose hymenophore and numerous, thick-walled encrusted cystidia characterize this genus. Other characteristics of importance are the monomitic hyphal system with clamped hyphae, hyaline and thin-walled spores and that the fungus produce a white pocket rot.

Erythromyces crocicreas (Berk. & Br.) Hjortst. & Ryv., **comb. nov.**
Basionym: *Hymenochaete crocicreas* Berk. & Br. in Journ. Linn. Soc. Bot. 14: 68 (1873)
≡*Porogramme crocicreas* (Berk. & Br.) Pat. in Bull. trimest. Soc. Mycol. Fr. 31: 77 (1915)
=*Hymenochaete innata* Cooke & Massee in Grevillea 15: 99 (1887). Holotype: Australia, Daintree River, on wood (K)

BASIDIOME resupinate, closely attached to the substratum, stratified, 0.25-1 mm thick. HYMENOPHORE strongly pilose by protruding cystidia, cracking when dried, cinnamom brown to fawn-coloured, sometimes greyish in the herbarium. HYPHAL SYSTEM monomitic; generative hyphae thin-walled, (1.5-)2-4 µm wide, sometimes slightly encrusted, with clamp-connexions; other hyphae encrusted, mostly vertically arranged, with clamp-connexions which may be rather difficult to discern. CYSTIDIA numerous, acute, agglutinated, in KOH yellowish brown to reddish, strongly encrusted, thick-walled, generally 80-100 × 10-12 µm. BASIDIA clavate, in a dense palisade, commonly more or less pedunculate, 20-30 × 4-5 µm, with four sterigmata and a basal clamp-connexion. SPORES ellipsoid to narrowly ellipsoid, thin-walled, smooth, narrowing towards the apiculus, hyaline, 6-8 × 2.8-3.2 µm. The fungus discolour the wood reddish and the decay seems to be a white pocket rot.

Distribution: Africa (Gabon), Indonesia, Malaysia, Cambodia, Fiji, Philippines and Australia.

Veluticeps fusca Humphey & Long in Burt, Ann. Mo. Bot. Gard. 13: 329 (1926)

Note: Presumably this is the same as *V. berkeleyi*.

Hymenochaete [subg. *Veluticeps*] *hispida* Berk. ex Cooke in Grevillea 8: 149 (1880) = **Heterochaete delicata** (Kl. ex Berk.) Bres. in Hedwigia 53: 77 (1912) ≡ *Hydnum delicatum* Kl. ex Berk. in Ann. Mag. Nat. Hist. 3: 395 (1839)

Veluticeps philippinensis Bres. in Hedwigia 56: 302 (1915)

Note: The holotype at Kew (Luzon, D. Merril n.° 1279, Forestry Bureau 16821) is rather poor and neither basidia nor spores are present. The same was also stated in the original description "sporis, nec basidiis visis". The species is of uncertain application.

Hymenochaete [subg. *Veluticeps*] *vinosa* Berk. ex Cooke in Grevillea 8: 149 (1880) = **Lopharia crassa** (Lév.) Boid. in Bull. trimest. Soc. Mycol. Fr. 74: 479 (1958)

Note: This taxon was based on the same specimen as *Thelephora vinosa* Berk. in Hooker's Lond. Journ. Bot. 4: 60 (1845) not *Thelephora vinosa* Pers. Syn. Meth. Fung.: 578 (1801). Holotype of *T. vinosa* Berk.: Australia, Swan River, Drumm, n.° 160 (K).

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A NEW TAXON IN THE GENUS CORDYCEPS FROM CHINA

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ABSTRACT

A new species, *Cordyceps crassispora,* a close relative of the traditional medicinal fungus, *C. sinensis,* is described and illustrated from the plateau of Yunnan, China. Several collections were taken on the larvae of *Hepialus baimaensis* Liang at high elevations (near 4500 m.). The type specimen is deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Academia Sinica (HKAS).

汉文摘要

中国对虫草入药源渊流长，相传纪元前的神农氏和明朝的李时珍均尝百草辩性能。最近，作者在云南德钦白马雪山，海拔4500米处的白马蝙蝠蛾（ *Hepialus baimaensis* Liang ）幼虫体上发现一真菌新种：阔孢虫草（*Cordyceps crassispora* Zang,Yang et Li.sp.nov.）其模式存中国科学院昆明植物研究所隐花植物标本馆。

撰稿人：臧　穆、杨大荣、李朝达

Ancestral Chinese sought agents from nature to relieve their ills and discomforts, probably from their earliest years, and by experimenting with what their environment provided they recognized and used plants, fungi, etc., as medicine. It is said that in the prehistoric age Shen-Nong (1958: 102-200, Han dynasty), an herbalist, and Li Shi-zhen (1957: 1518-1593, Ming dynasty) tried various herbs and had themselves been poisoned many times. In China, where the cultural history is the oldest, it is understandable that it has inherited perhaps the richest store of ethnopharmacological tradition (Hu et al., 1980).

The traditional medicinal caterpillar fungal group is an example of these, such as *Cordyceps sinensis* (Berk.) Sacc., which appears to be endemic to the alpine region of southwestern China. It is a famous Chinese medicine as a tonic, and beneficial to gonadal activity and the relief of bronchial inflammation (Liu, 1980). The authors recently made numerous mycological and entomological explorations to the Deqen region of northwestern Yunnan, where they found a new species of the genus *Cordyceps* not previously reported, *C. crassispora.*

The Deqen (Atuntzu) region comprises the Yangtze drainage basin at latitude 28° 30' — 27° 35'. The Yangtze flows throughout in an arid, narrow gorge. From Deqen we follow the main road south for a short distance, then turn south-east (instead of west, where the main road leads to the Mekong), and climb in a zigzag steeply to a gap which leads to Bei-Ma Shan. (The Chinese Tibetians speak of Pad-Ma La, which has, however, nothing to do with the Chinese Han's "Bei Ma" [white horse]. It is the Tibetian's way of pronouncing Pad-Ma [the lotus], and Pad-Ma La means the Lotus Pass.] The slopes of the mountain are partly forested, where a brownish biotite-granite porphyry is to be found. On parts of Bei-Ma Shan the valley increases in depth and is densely wooded with *Picea likiangensis* (Franch.) Pritz. To the west the last of the snow-covered rocky peaks of Bei-Ma Shan are visible, the highest peak approximately 5137 m high. Below the snow-covered margins are alpine shrub-meadows filed with lovely genera, e.g., *Sassurea, Myconopsis, Kobresia,* and *Primula.* Especially *Polygonum, Pedicularis,* and *Potentilla* are commonly associated with shrubby rhododendrons.

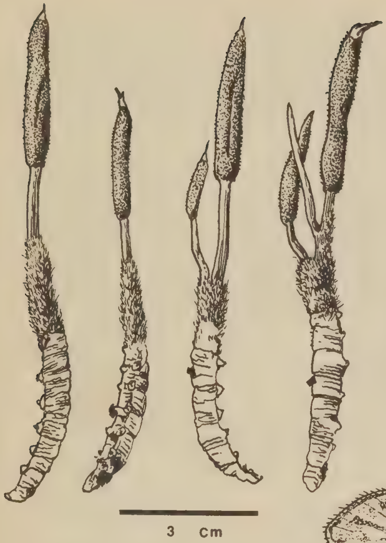
In the alpine shrub-meadow zone, the cold-loving fungi such as *Cordyceps sinensis* and its allies are to be found as high as 4200-4500 m. They are parasitic on the larvae of Lepidoptera, especially the bat moths. *Cordyceps sinensis* is parasitic on the larvae of *Hepialus armoricanus* Oberthür (Kang Ding, 4300-4500 m. alt., Sichuan; Yu Lung Mts., Li Jiang, 4200-4400 m. alt., Yunnan). *Cordyceps crassispora,* the new species, occurs on *Hepialus baimaensis* Liang, moths usually herbivorous on the rhizomes of *Polygonum viviparum* L., *P. affine* D. Don, *P. macrophyllum* D. Don, *P. glaciale* (Meisn.) Hook. f., *Astragalus balfourianus* Simpson, and *A. craibianus* Simpson, etc. From April to July caterpillar fungi could be located by the stromata which protrude from the soil in shrub-meadow slopes.

The Chinese caterpillar fungus first appeared under the name *Sphaeria sinensis* Berkeley in 1843. Later the description was emended and the species transferred to the genus *Cordyceps* by Saccardo (1883). The type specimen was collected from western Sichuan, China. We have collected a fungus closely related to *C. sinensis* from Deqen, which we believe should be recognized as a new species, and provide the following description.

Cordyceps crassispora Zang, Yang, et Li, sp. nov. (Fig. 1-4, 13-15)

Stromatibus clavatis, singularibus vel ramosis, 4.5-6.5 cm longis, 2-4 mm crassis, capitulis cylindricis vel clavatis, 2-3.5 × 2-4 mm, porphyro-brunneis, atro-violaceis, atro-brunneus; apice acerosis sterilibus; cortice pseudoparenchymato; peritheciis globoideis vel ovoideis, 200-450 × 190-420 μm, superficialibus, excelsis. Stipitibus 1.5-2 cm longis, 2-3.7 mm latis, aequalibus vel mentosis. Ascis cylindraceis, 170-220 × 7.8-10.4 μm, 4-sporis, ascosporis hyalinis vel luteolis, clavcatis, multiseptatis, 120-196 × 5.2-6.5 μm.

Figs. 1-8. *Cordyceps crassispora* and its host, *Hepialus baimaensis.* Figs. 1-4, *C. crassispora.* 1, ascocarps. 2, fertile part of the stromata. 3, asci and ascospores. 4, part of a section through the stromata. Figs. 5-8, *H. baimaensis.* 5. male genitalia, caudal aspect. 6, female genitalia, caudal aspect. 7, slough and adults. 8, wing venation.



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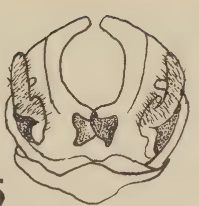

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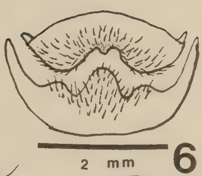

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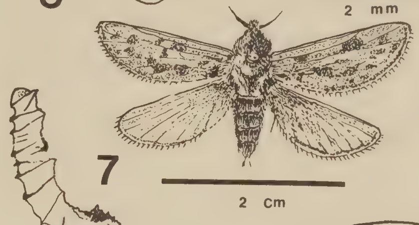

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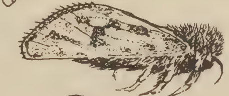

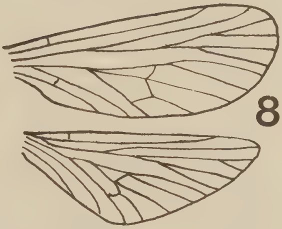

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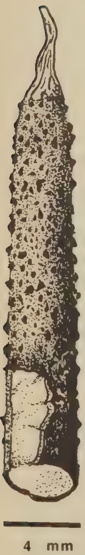

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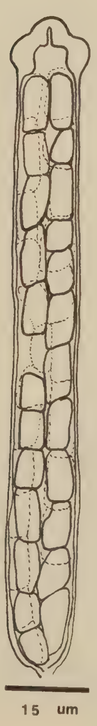

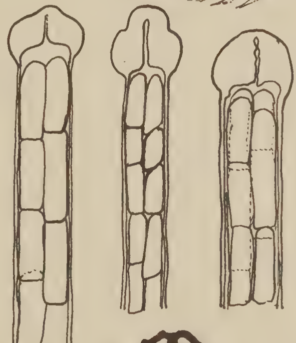

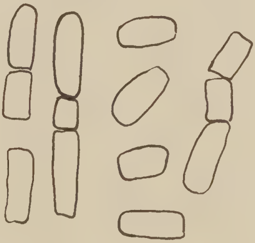

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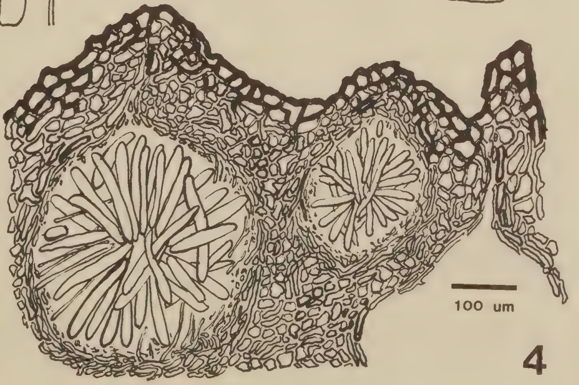

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In larvis Hepiali baimaensi, *Lepidopterae.*

Yunnan: Deqen (Atuntzu) Bei Ma Snow Mountain, 4600 m. alt., 24 VI 1985, D. R. Yang *157,* HKAS 22020 (typus); Deqen, Bei Ma Snow Mountain, 4300-4500 m. alt., 20 IV 1988, Y. C. Yu *1,* HKAS 22019 (paratypus); Deqen, Bei Ma Snow Mountain, 4900 m. on alpine meadow, 13 VII 1981, L. S. Wang *30,* HKAS 8203 (paratypus).

Stromata clavate, simple or occasionally 2 or 3 from host, 4.5-6.5 cm long, 2-4 mm diam., ascogenous portion three-fifths to one half the length, abruptly enlarged from the stipe, 2-3.5 cm long, 2-4 mm thick, purplish brown, dark violet, or dark brown; one with sterile acuminate apex 2-3 mm long, the apex apparently broken off in maturation, rough or punctate with the ostioles of the perithecia, with a cortex consisting of one layer of closely interwoven hyphae, pseudoparenchymatous in section; perithecia globoid or ovoid, 200-450 × 190-420 µm, almost entirely embedded in the stroma, but the ostioles projecting above the surface, black when dry. Asci cylindric, narrowing below, 170-220 × 7.8-10.4 µm with a hemispherical thickening of the wall at the apex. Ascospores hyaline or pale yellow, clavate, multiseptate, 120-196 × 5.2-6.2 µm, breaking into 1-celled segments 6.5-9.8 × 5.2-6.5 µm. Stipe 1.5-2 cm long, 2-3.7 mm thick, glabrous and striate above, below having a covering of very closely interwoven hyphae, usually forming tomentose tufts.

Host: larvae of *Hepialus baimaensis* Liang (Fig. 5-8).

This species differs from *Cordyceps sinensis* in having much shorter asci (170-220 × 7.5-10.4 µm) and wider and shorter segments of the ascospores (one-celled segments 6.5-9.8 × 5.2-6.5 µm), but the asci of *C. sinensis* are always longer (220-280 × 13 µm), the ascospores are filiform, not clavate, and break into one-celled, slightly narrower part-spores (9-15 × 4-5 µm); there are also clear differences in their hosts, *C. crassispora* parasitic on larvae of *Hepialus baimaensis,* but *C. sinensis* on *H. armoricanus.*

According to the description of Liu et al. (1989) the conidial stage of *Cordyceps sinensis* was found on *Hepialus* sp. collected in Kongding, Sichuan, in 1987. They described *Hirsutella sinensis* Liu, Guo, Yu & Zeng, and suggested that this was the anamorph of *C. sinensis.* Lie et al. (1989), in connection with their discussion of other names, note that *Paecilomyces hawkesii* Li, Xian & Chen (Chen et al., 1984) is probably not the anamorph of *C. hawkesii* Gray, but may be a contaminant. Liang (1985) described the simultaneous isolation of *Paecilomyces gunnii* Liang from mature stromata and from endosclerotia of *Cordyceps gunnii* Berk. (Fig. 11). *Scytalidium hepiali* Li (Fig. 10) was isolated from fresh specimens of *Cordyceps sinensis* collected in Hualong, Qinghai Prov. (Li and Sun, 1988).

The phialides of *Hirsutella sinensis* (Fig. 12) are given as acicular or subuli-

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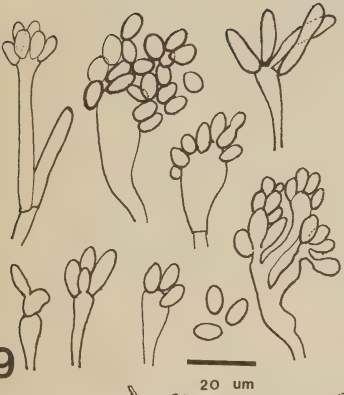
Figs 9-13. Conidial states associated with *Cordyceps.* 9, *Stachybotrys,* the conidial stage of *C. sinensis* (after Kobayasi, 1941). 10. Chains of arthroconidia of *Scytalidium hepiali* (after Li & Sun, 1988). 11. Phialides, conidia and chlamydospores of *Paecilomyces gunnii* (after Liang, 1985). 12. Phialides and conidia of *Hirsutella sinensis* (after Liu et al., 1989). 13. The conidial stage of *C. crassispora* (HKAS 22011)

Figs. 14-15. Conidia of *C. crassispora* (HKAS 22011). Scale = 20 µm.



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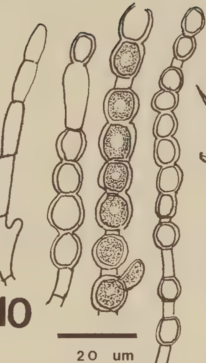

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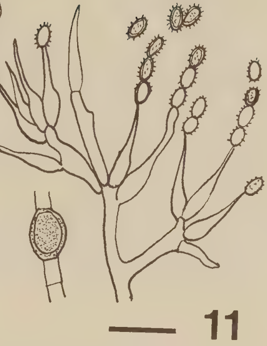

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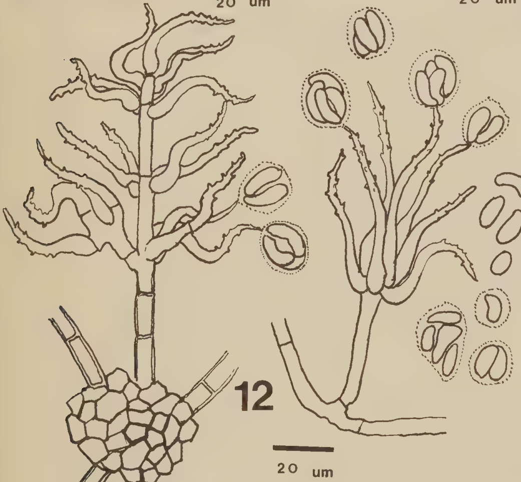

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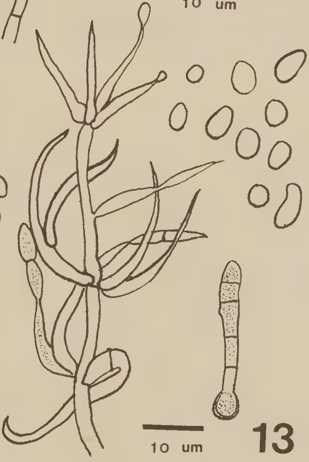

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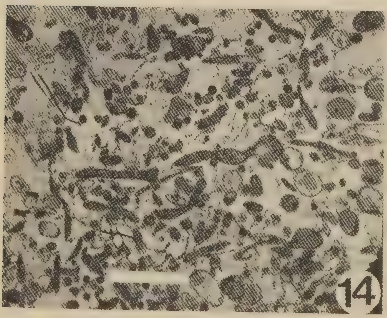

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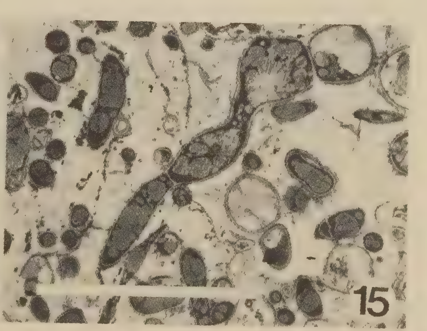

15

form, with verrucose apices 17.3-47.6 × 1-3.5 µm, and conidia 5.4-14 × 3.2-5.4 µm including the mucus covering. Recently two collections of the conidial stage of *Cordyceps crassispora* on *Hepialus baimaensis* from Deqen have been seen by us. The phialides are subulate, curved, gradually narrowing to acuminate apices, with smooth, ovoid to ellipsoid, curved-clavate or irregular conidia 5.2(-6) × 2.6-3.5 (-5) µm without mucus covering. This state (Figs. 13-15) is amply distinct from all other taxa treated in this paper.

The conidial stages of entomogenous fungi are well known and readily recognized. There are several important genera, such as *Hirsutella, Tilachlidium, Synnematium* (Mains, 1951), and *Stachbotrys* (Kobayasi, 1941; Fig. 9). However, the anamorphs of *Cordyceps sinensis* and its allies are very imperfectly understood, despite the cultural studies carried out by other workers (Chen et al., 1983; Li and Sun, 1988; Liu et al., 1989). Producing the teleomorphic ascomata in vitro has apparently never been recorded.

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INTERFERTILITY STUDIES ON THREE SPECIES OF CORTICIACEAE

by

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SUMMARY

The type of interfertility of three species of Corticiaceae, namely Epitheleopsis bosei De, Gloeocystidiellum sinuosum Freeman, and Metulodontia indica (Thind and Rattan) Rattan, has been studied. E. bosei is bipolar and causes brown rot but G. sinuosum and M. indica are tetrapolar and cause white rot.

Studies on interfertility in Hymenomycetes received great impetus particularly when Nobles (1958) attributed taxonomic importance to this character and advanced the hypothesis that, in the Polyporaceae, species which possess tetrapolar type of interfertility are associated with white rots, while species with bipolar interfertility cause brown rots. From the evolutionary point of view she considered the tetrapolar type to be more advanced than the bipolar type.

Information so far obtained from the members of the Polyporaceae generally supports this view of Nobles's with a few exceptions (Sen and Shegal 1967; Van der Westhuizen 1963).

Though sexuality and cultural characteristics of several members of the Corticiaceae have been worked out, attempts to see whether the viewpoint of Nobles based on the members of the Polyporaceae also holds true for wood-rotting members of the Corticiaceae have very rarely been made.

The present paper gives the results of interfertility tests of three species of Corticiaceae occurring in India together with a note on the type of rots they produce.

Single-spore cultures were made from fresh sporophores collected by the author, and the type of polarity was determined by pairing the haploid isolates in all possible combinations. The distribution of mating types among the monosporous isolates is shown following the methods of Nobles (1943) and Nobles et al. (1957). The conventional symbols A_1 A_2 in bipolar species and A_1 A_2 B_1 B_2 in tetrapolar species are used to designate the alleles governing interfertility. Sporophores are deposited in the Mycological Herbarium of Burdwan Raj College,Burdwan, West Bengal, India (BRCMH). Names and isolate numbers of the voucher herbarium specimens are listed.

1. *Epitheleopsis bosei* De, Int. J. Mycol. Lichenol. 4: 59. 1989.
   BRCMH 8411 : sporophore collected from dead fallen branch of an unknown angiosperm; causing brown rot.
   A_1 : 1,3,4,6,10,13,14,20
   A_2 : 2,5,7,8,9,11,12,15,16,17,18,19
   The species is bipolar.

2. *Gloeocystidiellum sinuosum* Freeman, Systematic Botany 6: 426. 1981.
   BRCMH T 121 : sporophore collected from a dead log of *Shorea robusta* Gaertn.; causing white rot.
   A_1 B_1 : 1,2,18,19
   A_1 B_2 : 3,6,10,11,20
   A_2 B_2 : 5,8,9,13,14,15,17
   A_2 B_1 : 4,7,12,16
   The species is tetrapolar

3. *Metulodontia indica* (Thind and Rattan) Rattan, *The Resupinate Aphyllophorales of the North Western Himalayas*, p.316. 1977. J. Cramer, Vaduz.
   BRCMH T 42 : sporophore collected from dead wood of *Shorea robusta* Gaertn.; causing white rot.
   A_1 B_1 : 1,7,13,14,15
   A_1 B_2 : 3,6,11,12,20
   A_2 B_2 : 4,5,9,10,17,19
   A_2 B_1 : 2,8,16,18
   The species is tetrapolar.

From the results obtained it may be concluded that the hypothesis of Nobles (1958) for the Polyporaceae also finds support in *Epitheleopsis bosei* De, *Gloeocystidiellum sinuosum* Freeman, and *Metulodontia indica* (Thind and Rattan) Rattan, three wood-rotting members of the Corticiaceae. A/review of literature shows that some other members of Corticiaceae like *Merulius aureus* Fr. (Ginnns 1976), *Crustoderma opuntiae* Nakas. & Gilb., *Gloeocystidiellum porosum* (Berk. et Curt.) Donk, *Sparassis radicata* Weir., *Trechispora vaga* (Fr.) Liberta (Boidin and Lanquetin 1984; Gilbertson, Burdsall and Larsen 1975; Nakasone and Gilbertson 1982), etc., also support the hypothesis of Nobles (1958).

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Acremonium uncinatum, a new endophyte in *Festuca pratensis*

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The occurrence of fungal endophytes and the recognition of their significance in forage grass toxicoses is of great actuality (SIEGEL et al., 1987). CLAY (1988) reviewed the coevolution of the Balansieae (Clavicipitaceae) endophytes with their grass hosts and made an ecological distinction between *Acremonium* anamorphs, where the fungus has lost its sexual capacities and does not cause visible disease symptoms on the plant, and the teleomorphic species [*Atkinsoniella hypoxylon* (PECK) DIEHL, *Balansia* spp., *Myriogenospora atramentosa* (BERK. & M.A. CURTIS) DIEHL] which inhibit sexual reproduction in their hosts. *Epichloë typhina* (PERS.: FR.) TUL., with its anamorph *Acremonium typhinum* MORGAN-JONES et W. GAMS, apparently takes an intermediate position, being typically anamorphic in vitro, in vivo producing mainly the teleomorph and conferring complete or partial sterility on its host.

Several grass endophytes representing anamorphs of the Clavicipitaceae tribe Balansieae have been accommodated in the sect. *Albo-lanosa* of *Acremonium* erected by MORGAN-JONES & W. GAMS (1982). Since then four additional species have been described by LATCH et al. (1984), WHITE et al. (1987) and WHITE & MORGAN-JONES (1987a and b); the last named authors have also provided a key to the section. This section is rather remote in the genus; it comprises usually slow growing and poorly sporulating species; the intricate, densely sporulating aerial mycelium typical of the genus is absent; moreover, the phialides often lack a basal septum. It is remarkable that three of the six known taxa have been isolated from several species of *Festuca*, with a considerable degree of specificity. In this paper we report on a further species, isolated in Switzerland from plant-breeding material as well as from plants of *Festuca pratensis* HUDS. growing in the wild.

Material and Methods

Endophytes were isolated from several cultivars of *F. pratensis* grown at the Swiss Federal Agricultural Research Station in Changins (Nyon), Switzerland, as well as from plants of the same species growing in the wild and collected at different locations in Austria, France, the Federal Republic of Germany, Italy and Switzerland. The material was taken to the laboratory in polyethylene bags and processed within 24 h. Short segments of young leaves used for isolation were thoroughly washed in running water and dipped in 96% ethanol before surface sterilization was performed using sodium hypochlorite (BACON et al., 1977). After surface sterilization each segment was placed onto 2% malt extract agar (MEA) or Difco potato-dextrose agar (PDA) and incubated at ambient temperature until fungal growth was visible, usually after two to four weeks. The endophytes were then transferred to MEA slants. Endophytes in the leaves were detected directly by histological examination as described by LATCH & CHRISTENSEN (1982). Growth of the fungus was observed on MEA, PDA, and oatmeal agar (OA); to study temperature requirements, the strains were incubated at 5º, 15º, 20º, 25º, 30º and 37º C in 90 mm diam. Petri dishes containing 2% MEA and the linear growth was measured after 30 days.

Acremonium uncinatum n. sp. Fig. 1

Coloniae lente crescentes, albae vel roseo-bubalinae, hyphis aeriis numerosas phialides proferentibus. Phialides singulae vel binae, saepe ad basim septo egentes, aculeatae, rectae vel modice flexuosae, 9-18(-25) µm longae, e 1.5-2 µm ad 0.6-1 µm gradatim angustatae, saepe lateraliter proliferantes. Conidia pauca in quaque phialide, uncinata, 5-13 µm longa, 1.0-2.0 µm lata, saepe lateraliter proliferantia, conidia secundaria generantia vel anostomosantia.

Holotypus CBS 235.89, isolatus e *Festuca pratensi*, in Helvetia, in pago Changins vocato, leg. D. Schmidt, januario 1989.

Colonies on 2% MA, OA and PDA slow-growing, less than 1 cm diam in 20 days, forming a rather compact, centrally raised, otherwise thin, whitish to rosy buff felt of aerial hyphae, from which numerous phialides arise. Reverse darker rosy buff. Optimum growth on MEA (all strains) at 25º C 15 mm after 30 d, no growth at 30º C. Exposure of the cultures at 37º C for 30 d was lethal for the mycelium. Phialides singly or in pairs on a short base, often lacking a basal septum, aculeate, straight or slightly flexuous, 9-18(-25) µm long, from 1.5-2.0 µm gradually tapering to 0.6-1.0 µm. Secondary sympodial proliferation of the phialides commonly occurring. Conidia few in number, in irregular heads, rather firmly attached to the phialide, uncinate, the ends 5-13 µm apart, and 1.0-2.0 µm wide. The conidia have a strong tendency to proliferate laterally, generating microcycle conidia often while still attached to the phialide, or anastomosing with each other.

Material examined:

CBS 235.89 (E5, holotype), isolated from dwarf plant E130/1024 of breeding material of *Festuca pratensis*, Switzerland, Nyon, Changins, Swiss Federal Agricultural Research Station, January 1989, leg. D. Schmidt. CBS 233.89 (E4) from plant E 130/995, CBS 234.89 (E2) from plant E140/41, and CBS 236.89 (E3), from plant E140/101, all strains from *F. pratensis*, same site, date, and collector. CBS 542.89 (E 20), from a wild plant of *F. pratensis*, Switzerland, Ct. Neuchâtel, La Tourne, 1150 m.a.s.l, June 89, leg. D. Schmidt. E60, Changins, clone 1 of *F. pratensis*, ecotype from Schluderns, Italy, 17.7.89, leg. D. Schmidt. E61, Changins, clone 19 of *F. pratensis*, ecotype from Imst, Austria, 17.7.89, leg. D. Schmidt. E63, Changins, clone 38 of *F. pratensis*, ecotype from Col des Mosses, Switzerland, Ct. Vaud, 17.7.89, leg. D. Schmidt. CBS 544.89 (E64), Changins, clone 40 of *F. pratensis*, ecotype from Kollmar, Germany, 17.7.89, leg. D. Schmidt. E65, Changins, clone 45 of *F. pratensis*, descendant of ecotype from Schluderns, 17.7.89, leg. D. Schmidt. E66, Changins, clone 63 of *F. pratensis*, descendant of ecotype from Eschenbach, Ct. St. Gallen, 17.7.89, leg. D. Schmidt. E68, Changins, clone 114, descendant of ecotype from Gouglera-Giffers, Switzerland, Ct. Fribourg, 17.7.89, leg. D. Schmidt. CBS 543.89 (E69), Changins, clone 118 of *F. pratensis*, descendant of ecotype from Otzenbach, Switzerland, Ct. Bern, 17.7.89, leg. D. Schmidt. E70, Changins, clone 134 of *F. pratensis*, descendant of ecotype from Guebwiller, France, Alsace, 17.7.89, leg. D. Schmidt. E31, Changins, clone 217 of *F. pratensis* descendant of breeding material 'Prefest x Mosses', 14.7.89, leg. D. Schmidt. E32, Changins, clone 218 of *F. pratensis* descendant of ecotype from Schluderns, Italy, 14.7.89, leg.D. Schmidt. E34, Changins, clone 220 of cultivar 'Prefest', *F. pratensis*, 14.7.89, leg. D. Schmidt. E36, Changins, clone 222 of *F. pratensis*, descendant of ecotype from Kollmar(D), 14.7.89, leg. D. Schmidt. E38, Changins,

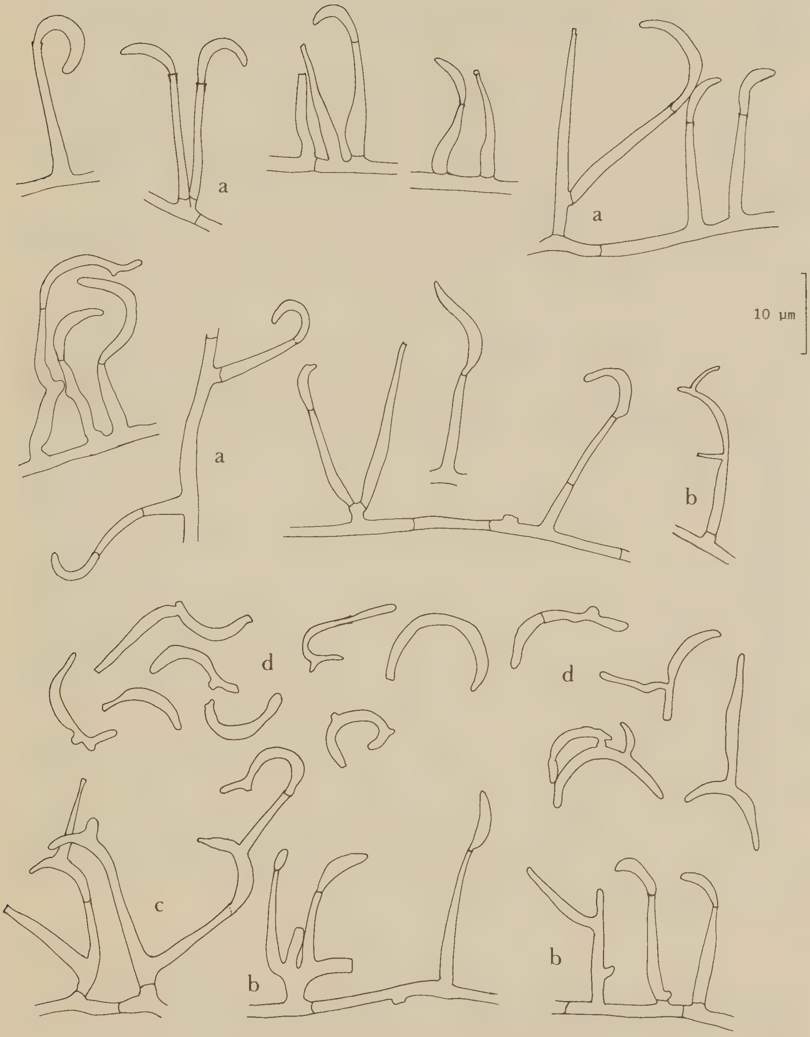

Fig. 1. *Acremonium uncinatum*, a. phialides with attached conidia, b. proliferation of phialides, c. phialides with attached conidia producing secondary phialides, d. conidia, some proliferating.

clone 224 of *F. pratensis* descendant of breeding material 'Mosses x Trifolium', 14.7.89, leg. D. Schmidt.
E40, Changins, from plant E 133/29 of *F. pratensis*, 28.7.89, leg. D. Schmidt.

A. uncinatum clearly belongs to *Acremonium* sect. *Albo-lanosa*. Its aculeate phialides which often lack a basal septum reveal a close affinity to *A. typhinum* and *A. coenophialum* G. MORGAN-JONES et W. GAMS. It is distinct from all species so far described by its strongly curved conidia and the pronounced tendency of sympodial proliferation in both conidia and phialides. In *A. chisosum* WHITE & MORGAN-JONES the phialides proliferate percurrently.

In the infected host, the mycelium has been observed subepidermally mainly in the leaf sheaths and the stem pith and appears as septate, sparsely branched hyphae running longitudinally between cells, as in all species of the section, e.g. *A. lolii* (LATCH & CHRISTENSEN, 1982).

A. uncinatum was first isolated from dwarf plants observed in breeding material of *F. pratensis* cultivated at Changins and selected for resistance to *Xanthomonas* wilt, *Drechslera* root and stem rot [*Bipolaris sorokiniana* (SACC.) SHOEMAKER], and rust (*Puccinia coronata* CORDA). The dwarf, infected plants show enlarged, distorted leaves; subsequent investigations, however, have revealed the presence of the endophyte also in all healthy-looking plants of the same breeding populations. The breeding material originates from several ecotypes of *F. pratensis* collected in Switzerland and neighboring countries 15-20 years ago; a few original ecotypes and their first descendants have been maintained in Changins by vegetative reproduction and *A. uncinatum* has been recovered from nine of them (a site in Austria: Imst, near Innsbruck; one site in France: Alsace, Guebwiller; a site in Northern Germany: Kollmar; one site in Italy: Schluderns, close to the Swiss and Austrian border; and five Swiss sites: Ct. Bern, Otzenbach; Ct. Neuchâtel, Col de La Tourne; Ct. St. Gallen, Eschenbach; Ct. Vaud, Col des Mosses and Ct. Fribourg, Gouglera-Giffers). The constant presence of the endophyte in the progeny of the infected parent clones as well as the histological observation of endophyte hyphae within the seeds indicate that *A. uncinatum* is very likely seed-borne; moreover, the constant presence of the endophyte in the selected clones indicates that *A. uncinatum* may be in some way beneficial to its hosts, e.g. by conferring on the grass resistance against infection by other fungi, an hypothesis already advanced by WHITE & COLE (1985, 1986) for *A. coenophialum* and the *Festuca versuta* endophyte.

A preliminary study conducted in several natural meadows indicates that endophyte infection is quite common in *F. pratensis* in Switzerland. *A. typhinum*, however, appears so far to be more common than *A. uncinatum*.

No exact data are available on toxin production by *A. uncinatum*. Preliminary results, however, show that plants infected by this endopyhte may contain as much as 2700 ppm lolines (M.R. SIEGEL, pers. comm.). This would be the first report of lolines being present with an endophyte other than *A. coenophialum*.

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A NEW SPECIES OF ACAULOSPORA ASSOCIATED WITH COCOA IN JAVA AND BALI (INDONESIA)

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ABSTRACT

During an investigation of Vesicular Arbuscular Mycorrhizal (VAM) fungi in the soils from plantations of *Theobroma cacao* L. (cocoa) in Java and Bali, a yellowish brown spore of a VAM fungus was regularly recovered by wet sieving. It appeared to be an undescribed species in the genus *Acaulospora*, and is described here for the first time as *A. walkeri*. The fungus is abundant and widely distributed under cocoa in Java and Bali.

INTRODUCTION

Samples of the top 10 – 20 cm of soils were collected from under cocoa at plantation sites distributed throughout Java and Bali. Following wet sieving and decanting, spores were removed under a dissecting microscope from suspensions in water or 5% Formaldehyde using swan-necked forceps. At all of the eleven sites investigated in Java and Bali an unknown species of *Acaulospora* was the most abundant spore type recovered, the average density being 440 spores per kg soil, with figures as high as 1278 spores per kg being recorded for one site (Kramadibrata 1989). In view of the importance of this taxon within the community of VAM fungi in soil under cocoa in Indonesia it is here described as a new species *Acaulospora walkeri*.

Acaulospora walkeri Kramadibrata & Hedger, sp. nov.

Sporae in solo singulatim iveniuntur, hyalina e hypha lateraliter exorientes, quae ipsa sporifero e sacculo producitur, sacculo ipso (sit spora statu maturo) collapso. Sacculus sporiferous hyalinus vel albus, globosus vel subglobosus, 80 – 120 x 100 – 150 μm diam., muroindutus hyalino vel viridi, 0.5 – 1.0 μm lato et hypha laterali quae sacculi in regione circa 200 x 10 – 20 μm et e spora fastigata est. Sacculus ipse nonnumquam minute asperatus minutos ob soli particulos est, modo granulorum in superficie visu.

Sporae globosae vel subglobosae vel reniformes, pallidae-brunnae vel flavo-brunnae ad brunnae, 140 – 200 x 140 – 200 μm diam., in superficie laeves licet etiam ab eo investigentur quod anglice redditur "scanning electron microscope", saepius circa 40 – 80 μm e sacculo sporifero productae, e hypha hyalina plusminusve 5 mm lata, et quaeque separatae cicatrice globoso vel irregulari, 10 – 20 μm diam.

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Spores are found singly in soil, arising laterally from a hyaline hypha, which is itself produced from a sporiferous saccule which collapses as the spore matures. The sporiferous saccule is hyaline to white, globose to subglobose, 80 – 120 x 100 – 150 μm diameter, with a hyaline to greenish wall, 0.5 – 1.0 μm thick. It gives rise to a hypha ≈ 200 μm long, which is 10 – 20 μm broad near the sporiferous saccule, but which tapers to 5 μm at its tip near the spore. The sporiferous saccule itself is sometimes minutely roughened on account of minute particles of soil, which appear like granules on the surface.

Spores are globose or subglobose or reniform, pale brown or yellow-brown to brown, 140 – 200 x 140 – 200 μm diameter. The surface is smooth; no surface markings were found under the scanning electron microscope. Spores are formed at about 40 – 80 μm distant from the sporiferous saccule, from a hyaline hypha ≈ 5 μm broad, and each is separated by a globose to irregular scar 10 – 20 μm wide left on the spore.

The wall is structured in two wall groups, A and B. Wall group A consists of walls 1 and 2. Wall 1 is a smooth unit wall, sometimes difficult to rupture, hyaline to pale yellow, or yellow-brown in colour, 0.5 – 1.0 μm thick. Wall 2 is also a smooth unit wall but is hyaline and 1.0 – 2.0 μm thick. It is tightly bound to wall 1. Wall group B consists of two walls, 3 and 4. Wall 3 is hyaline, unit, sometimes finely ornamented, 0.5 – 1 μm thick. Wall 4 is amorphous, 1.0 – 2.0 μm thick and sometimes difficult to see.

The muronym (Walker 1983, Morton 1986) is A(UU) B(U_o A). The murograph is shown in figure 1. The sporiferous saccule, spores and wall structures are illustrated in figures 2 – 6.

CHEMICAL CHARACTERISTICS

Reactions to Melzer's reagent are: (a) fresh spores from pot culture, walls 1 and 2 do not react, walls 3 and 4 become purple; (b) after prolonged storage in 5% formaldehyde, walls 1 and 2 remain unreactive, but walls 3 and 4 colour brown in Melzer's, and ornamentation in wall 3 becomes obvious.

ETYMOLOGY

The specific epithet is given in honour of Dr. C. Walker.

COLLECTIONS EXAMINED

HOLOTYPE: West Java Province - Cianjur County: XII State Plantation Company (Rajamandala Plantation), Rama 2, 28 April 1987, KK 277. Deposited at Herbarium Bogoriense, Bogor, Indonesia (BO).

ISOTYPES: West Java Province - Cianjur County: XII State Plantation Company (Rajamandala Plantation), Rama 1, 28 April 1987, KK 275; Rama 3, 28 April 1987, KK 202 and KK 202a. Banjar County: XIII State Plantation Company (Batulawang Plantation), Batugajah Plantation, BG4, 6 May 1987, KK 322 and KK 323; Pangandaran Plantation, PND 1, 8 May 1987, KK 144; PND 5, 8 May 1987, KK 340: PND6, 8 May 1987, KK 345.

Central Java Province - Jepara County: XVII State Plantation Company (Beji Plantation), Beji Tengah 11, 3 April 1987, KK 228.

East Java Province - Malang County: Pancursari Subdistrict: Pancursari village, MLGS2, 30 March 1987, KK 212.

Bali Province - Jembrana County: Pekutatan Subdistrict: Puluhan village, Bali 2, 25 March 1987, KK s.n.

All isotypes are deposited in Herbarium Bogoriense except for KK 212 which is deposited in Mycological Herbarium, Department of Biological Sciences, University of Wales at Aberystwyth, Dyfed, U.K.

POT CULTURE: Pot cultures with *Lolium perenne* have been made, mixed with a *Glomus* species. Attempts are being made to produce single species pot cultures.

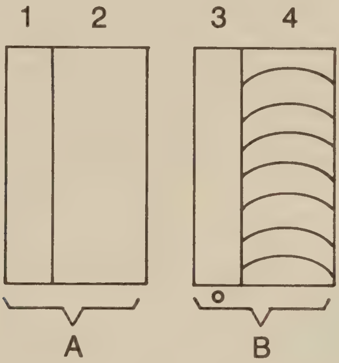

Fig. 1. Murograph of spores of Acaulospora walkeri. Arabic numerals indicate each wall in order from the outside of the spore; letters indicate wall groups. The conventions used are described by Walker (1983) and Morton (1986).

DISCUSSION

All collections of spores of *A. walkeri* made from cocoa soils throughout Java and Bali appeared to be very similar. Most field collections from Bali lacked sporiferous saccules, but were clearly *A. walkeri*. Wall group A in some intact spores appeared to consist of three walls, but careful examination of crushed spores never confirmed the presence of a third wall. Some spores also had outer walls (wall 1) which were somewhat reddish brown. Wall group B (walls 3 and 4) was always distinct and easily separable from wall group A when spores were crushed. By crushing it was usually possible to see the two tightly bound walls 3 and 4, but sometimes, in intact spores, the two walls were more difficult to distinguish. The ornamentation on wall 3 was most obvious in formaldehyde preserved spores, especially in Melzer's reagent. The amorphous nature of wall 4 was obvious in spores mounted in lactophenol. Spores of *A. walkeri* could easily be picked out under the dissecting microscope from sample preserved in 5% Formaldehyde, because of their smooth surface, and glittering or sparkling appearance.

A. walkeri resembles the description of *A. delicata* Walker, Pfeiffer & Bloss (1986) but the spores of the latter are smaller (80 – 125 (150) x 80 – 110 (140) μm in *A. delicata*, compared to 140 – 200 x 140 – 200 μm in A. walkeri) but both have a sparkling appearance. Fresh spores of *A. walkeri* are also much darker in colour than those of *A. delicata*. Although *A. walkeri*, like *A. delicata*, has two thin unit walls in wall group A, they are rather rigid compared with those in *A. delicata*.

Wall group B in *A. walkeri* resembles group B in *A. delicata*, since wall 3 can be finely ornamented in both, but in spores of *A. delicata* wall 4 is membranous, not amorphous as in *A. walkeri*. *A. walkeri* is also similar to *A. appendicula* Spain, Sieverding & Shenck (Shenck, Spain, Sieverding & Howeler 1984) the spores of which are slightly larger (170–) 250 (–390) µm. However, the spores of *A. appendicula* are a dull yellowish cream to orange tan colour, and the wall structure is different. Although *A. appendicula* has four walls in two groups they are all unit walls. Wall group A is thicker than in *A. walkeri*, i.e. 8–16 (–20) µm for wall 1 and 4–6 µm for wall 2, which also differs in having a reticulum. In wall group B, wall 3 is much thicker than in *A. walkeri*, 4–8 µm, and also has an alveolate reticulum; in addition, wall 4 (2–10 µm thick) is a unit wall.

With regard to its mycorrhizal associations in the field, this spore type was found in soil samples collected from plantations, but a number of other higher plants were commonly present, and thus could also have acted as phytobionts. They included grasses, clove, banana, coconut, and cardamom. *A. walkeri* was also collected from soils in Nongkojajar, Purwodadi, East Java, not planted with cocoa. Here the hosts could have included apple, clove and coffee.

ACKNOWLEDGMENTS

One of us (K.K.) is grateful to the British Council, the Overseas Development Administration and Pusat Penelitian dan Pengembangan Biologi - Lembaga Ilmu Pengetahuan Indonesia (Research and Development Centre for Biology - The Indonesian Institute of Sciences) for financial support and facilities. She also thanks the owners of cocoa plantations who allowed her to take soil samples. We thank Dr C. Walker for his advice and Dr D. Minter for the Latin diagnosis.

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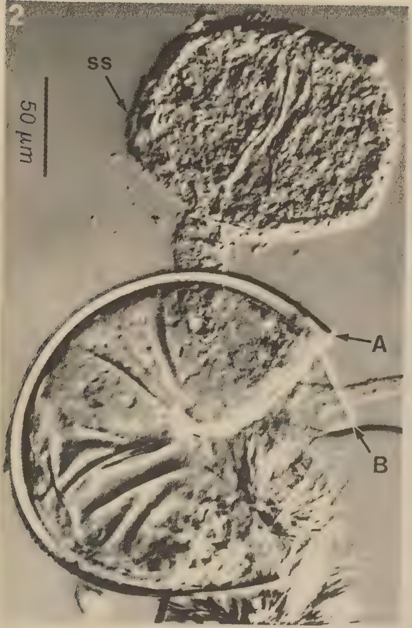
Acaulospora walkeri. –Fig. 2. Crushed spore (S) attached to collapsed sporiferous saccule (SS); wall groups A & B are arrowed. –Fig. 3. Crushed spore with intact wall group A (arrowed) and ruptured wall group B (arrowed). –Fig. 4. Crushed spore showing details of wall structure; walls 1 & 2 (wall group A) are arrowed and can be seen separated from walls 3 & 4 (wall group B) also arrowed. –Fig. 5. Scanning electron micrograph of groups of spores showing range of shape and size. – Fig. 6. Scanning electron micrograph showing smooth surface of spore and circular attachment scar (as) left by the subtending hypha.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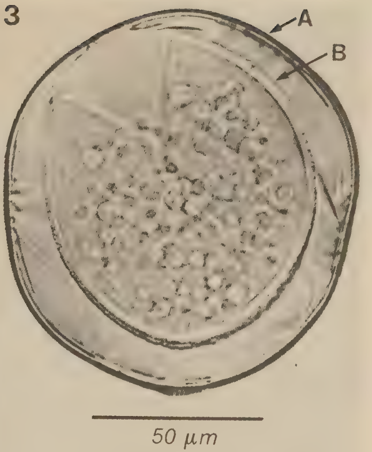
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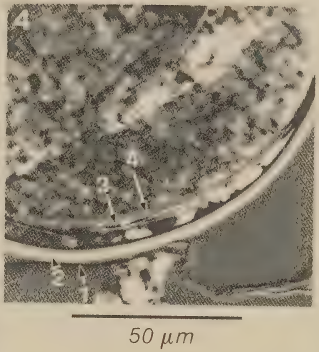
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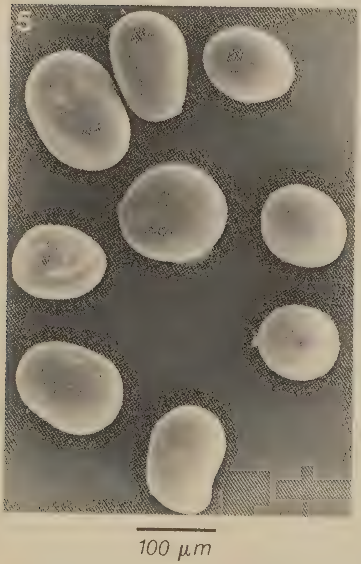
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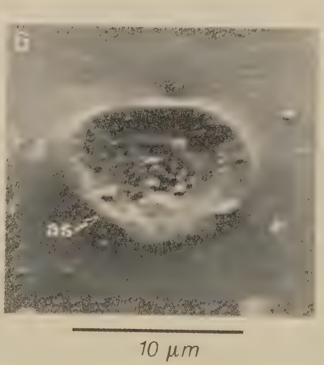
6
as
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ALTERNARIA THEMES AND VARIATIONS (27-53)

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PROLOGUS

In continuation of a series of papers primarily on *Alternaria* (Simmons 1981, 1982, 1986a), a new species *A. limicola* E. Simmons & M. Palm is described from Mexican lime (Key lime), *Citrus aurantiifolia* (Christm.) Swingle. *A. citri* Ellis & Pierce is discussed on the basis of its type specimen (long thought to be non-existent or lost). Other novelties presented are *A. hesperidearum* (Pantanelli) E. Simmons, comb. nov., on several citrus species; *A. pellucida* E. Simmons, sp. nov., on Satsuma orange; *Ulocladium obovoideum* E. Simmons, sp. nov., on lemon; *Stemphylium rosarium* (Penzig) E. Simmons, comb. nov., on lemon; and *A. macalpinei* E. Simmons, nom. nov. (syn. *Macrosporium citri* McAlpine, non *A. citri* Ellis & Pierce). Opinions are given on the status of each of the 20 names and variants thereof that have been published for phaeodictyoconidial hyphomycetes described from Rutaceae as well as on the identity of each pertinent fungus.

IX. ALTERNARIA AND OTHER PHAEODICTYOCONIDIAL HYPHOMYCETE TAXA ON RUTACEAE

Conventions employed. Epithets of *Citrus* species are retained as they originally appear on collections or in publications cited. Herbarium and culture collection abbreviations are, insofar as possible, those listed in Holmgren et al. (1981); they appear here in boldface type, e.g., **IMI**, **CBS**. Reference to an Article of the International Code of Botanical Nomenclature (Greuter, 1988) is in the format: ICBN 9.2. Reference to my own record books of material studied is in book-page format, e.g., EGS 39-090. Routine culture conditions are PCA, Hay decoction, and 20% V-8 juice agars in plastic Y-plates at ca. 22C under a cool-white fluorescent light/dark, 8/16 hr. cycle. Microscopic details (e.g., septation, color, wall ornamentation) are recorded from observations made at 500X using bright field light transmitted through a blue filter of medium density; phase contrast and Nomarski optics are not used in establishing basic descriptions.

A New Species on Mexican Lime

27. **Alternaria limicola** E. Simmons & M. Palm, sp. nov.

An extensive literature has developed since 1981 on a disease primarily of young shoots and leaves of *Citrus aurantiifolia* (Christm.) Swingle in commercial Mexican lime (Key lime) orchards in Mexico. Comprehensive bibliographies, mostly of phytopathological nature, are found in reviews by Becerra et al. (1988) and by Medina Urrutia et al. (1988).

Early studies and reports of the disease emphasized a belief that a bacterium *Xanthomonas campestris* (Pammell) Dowson pv. *citri* (Hasse) Dye probably was the causal agent; the common name "bacteriosis" of Mexican lime became current. However, isolation of the suspected bacterium from symptomatic tissue was inconsistent.

Attention then turned to an *Alternaria* species that could be isolated consistently from typical lesions. Inoculation attempts with conidia of this *Alternaria* resulted in development of typical field symptoms (Garza López 1988). The name "citrus leaf spot disease" (mancha foliar de los citricos) has replaced "bacteriosis" as the suggested common name of the disease. Garza L. (l.c.) considered the fungus to have characteristics different from those reported for *A. citri* Ellis & Pierce and to be more nearly comparable with those reported for species similar to *A. zinniae* M. B. Ellis.

This *Alternaria* species first came to my attention in 1980 in the form of a culture IMI 239651, which originally had been studied in March 1979 at the Commonwealth Mycological Institute, Kew, as an isolate from a leaf of *Citrus aurantiifolia* grown in Colima, Mexico. Dr. Paul Kirk had recognized it as being unusual, possibly undescribed, and had assigned it a study designation *Alternaria* tax. sp. XLI in the Institute's series of accessions requiring further specialist work.

Nine isolates of an *Alternaria* species were received in May 1989 from Dr. Mary Palm (USDA/APHIS, Beltsville, MD), who had isolated them recently from leaf lesions of Mexican lime trees in Mexico. The 1979 strain from CMI (now CABIMI) and those from Dr. Palm all are of the same distinguishable species, which has not previously been described and named in valid publication.

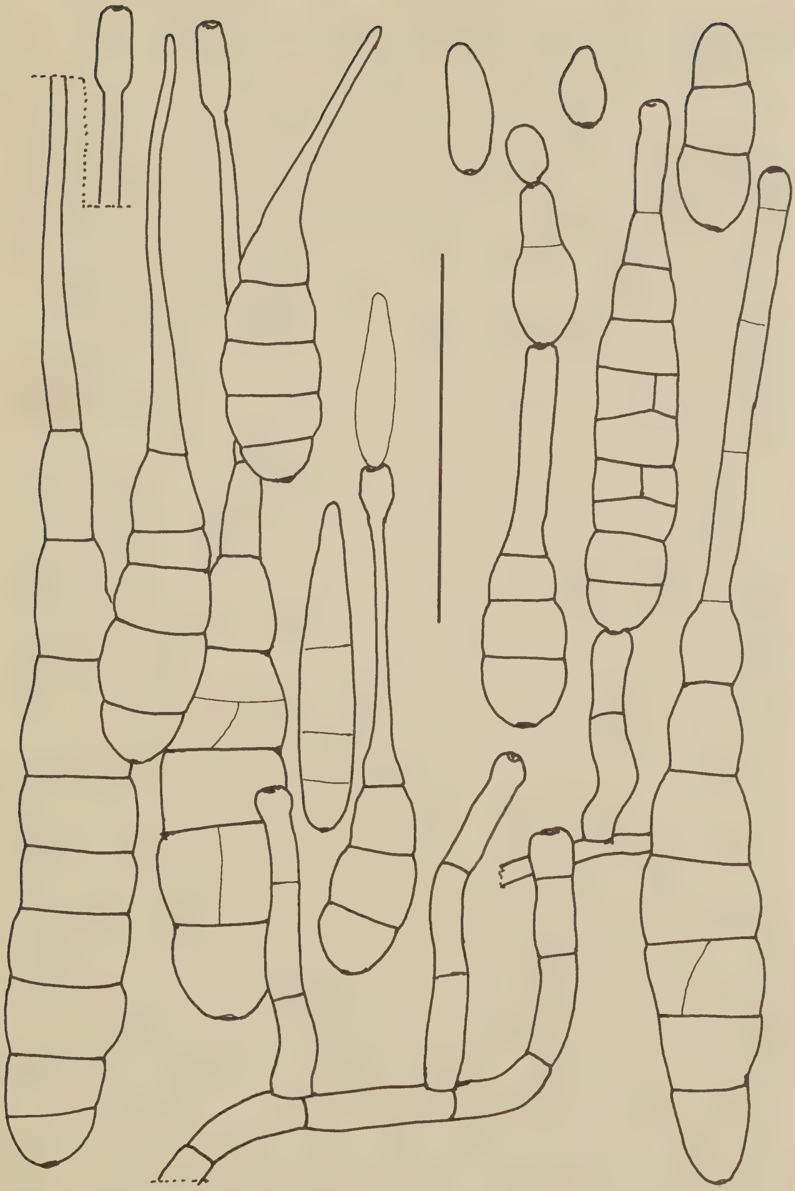

Fig. 40. Alternaria limicola; patterns of chain formation in culture, ex Type. Magn.: vertical bar = 50μm.

Alternaria limicola E. Simmons & M. Palm, sp.nov.
(Etym.: Ar. *lim*; Prov. *limo*) Fig. 40-41

Ex culturis in agaris PCA descripta. Conidiophora juventute 50-75 x 4-5µm, maturitate ad 150µm per extensiones 1-2 geniculatas. Conidia juventute ovata vel obclavata, 1-septata, 15-22(-30) x 5-8µm; maturitate longiellipsoidea, eurostrata aut pseudorostrata, 140-190 x 16-22µm (corpore 75-100 + rostro 60-90µm), dilute fulva, laevia, 5-7(-12) tranverse et 1-2(-4) longitudine septata. Sporulatio in catenis simplicibus conidiorum 2-4, vel in maturitate ramosis conidiorum 8-10 vel pluribus. Habitatio typi in foliis et surculis Citrus aurantiifolia (Christm.) Swingle, Colima, Mexico. Typus: partes ex EGS 39-070 (ex isol. M. Palm, May 1989) desiccatae et in BPI (holotypus) et pro isotypus saltem in IMI et NY conservandae.

The most stable isolates of *Alternaria limicola* grow at moderate speeds in culture, developing colonies 10-15 mm. diam. within 3 days. There is essentially no non-sporulating aerial mycelium; radiating surface mycelium gives rise at first to numerous, scattered (on PCA and Hay) or (on V-8) very abundant, densely crowded, simple to geniculate-branched conidiophores. Sporulation of colonies on V-8 becomes so dense that it obscures underlying hyphal elements; sporulation on PCA and Hay is sparse at three days but becomes abundant within one week.

Conidiophores in young colonies usually fall within a length range of about 50-75µm (x 4-5µm diam); they become longer (to about 150µm) through 1-2 geniculate extensions past successive terminal conidiogenous sites. Each conidiophore readily produces a simple chain of usually 2-4 long-beaked conidia; geniculate extensions of a conidiophore may produce similar chains; it is usual for chains to lengthen to 8-10 conidia in colonies 2-3 weeks old. Secondary sporulation also may arise from a short 1-2-celled conidiophore produced laterally from a conidial body cell, laterally from a pseudorostrum (secondary conidiophore), or from a conidial cell adjacent to the basal spore scar (Fig. 41).

Juvenile conidia are ovate or obclavate, becoming broadly ovate or long obclavate with a narrowed apex, and 15-22(-30) x 5-8µm in size at the time that the first transverse septum is produced. Two patterns of conidium development to maximum size become apparent at this stage. In one (Fig. 40, right of bar), an enlarging ovate conidium retains a rounded apex and is essentially beakless until it produces a short to long, broad, strong, apical secondary

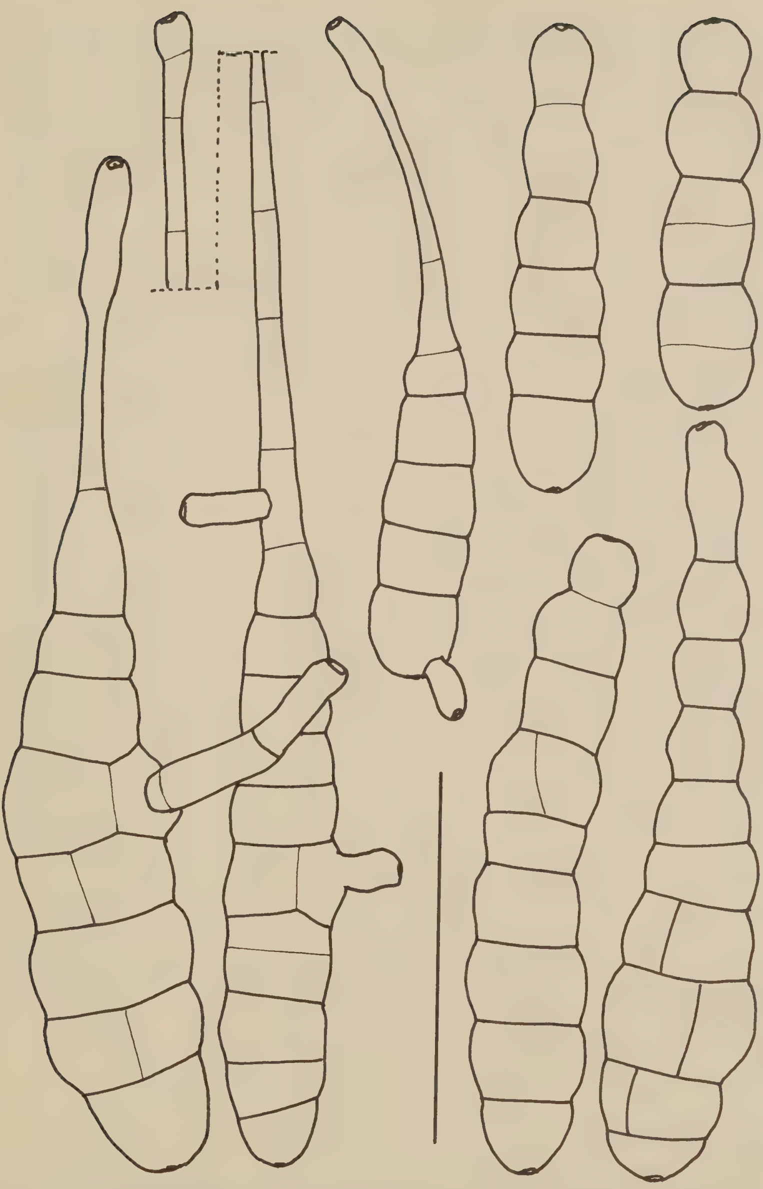

Fig. 41. Alternaria limicola; typical rostrate and erostrate conidia, ex Type. Magn.: vertical bar = 50µm.

conidiophore 10-100 x 4-5µm; in the other (Fig. 40, left of bar), the narrowed apical cell of an enlarging obclavate conidium gradually develops into a long, narrowly tapering, filamentous true beak 35-70 x 3.0µm whose apex becomes converted abruptly into a short, broad secondary conidiophore 7-10 x 5µm. The final overall dimensions of these two kinds of conidia may be identical, but the patterns of development through to secondary apical sporulation are strikingly different.

A high percentage of the dilute yellowish tan, smooth-walled conidia (walls minutely, densely punctate when viewed with Nomarski optics) reach a size range of about 140-190 x 16-22µm, with the spore body accounting for 75-100µm and the beak or secondary conidiophore for 60-90µm of the total length. Conidia in this size range have 5-7(-10) major and 1-2 secondary transverse septa plus one longitudinal or oblique septum in each of 1-2(-4) of the broadest divisions. The major transverse septa are well-defined and strong; secondary transverse septa and the very few longitudinal and oblique ones usually are very pale and, apparently, fragile. Most of the primary transverse septa seem to retain a fixed diameter after they are formed and thus impose growth restrictions on the otherwise expanding conidium wall; this septal constraint on enlarging conidia often becomes so pronounced that the cells of a conidium appear almost moniliform. A similar though usually less symmetrical ballooning of conidium cells often is seen in isolates of large-spored *Alternaria* that demonstrably carry internal hyphal parasites or that have aberrant growth patterns in culture. Typical isolates of *Alternaria limicola* show no such evidence of pathology; for the present, at least, the production of remarkable numbers of distinctively constricted, moniliform conidia is taken to be normal for the species and diagnostically helpful.

Alternaria limicola is easily distinguishable by reason of its large and distinctively constricted conidia from typical *A. citri* Ellis & Pierce and from all the other numerous herbarium specimens and isolates that we have examined from rutaceous substrates.

An Old Species Usually Misunderstood

28. **Alternaria citri** Ellis & Pierce Fig. 42

in N. B. Pierce (1902), Bot. Gaz. 33: 234. *In oranges in California.* Lectotype: BPI, *Macrosporium citri* E. & E., on (Oranges) *Citrus* sp., California, Jan. 1892, Newton B. Pierce, ex Herb. Ellis (EGS 07-106).

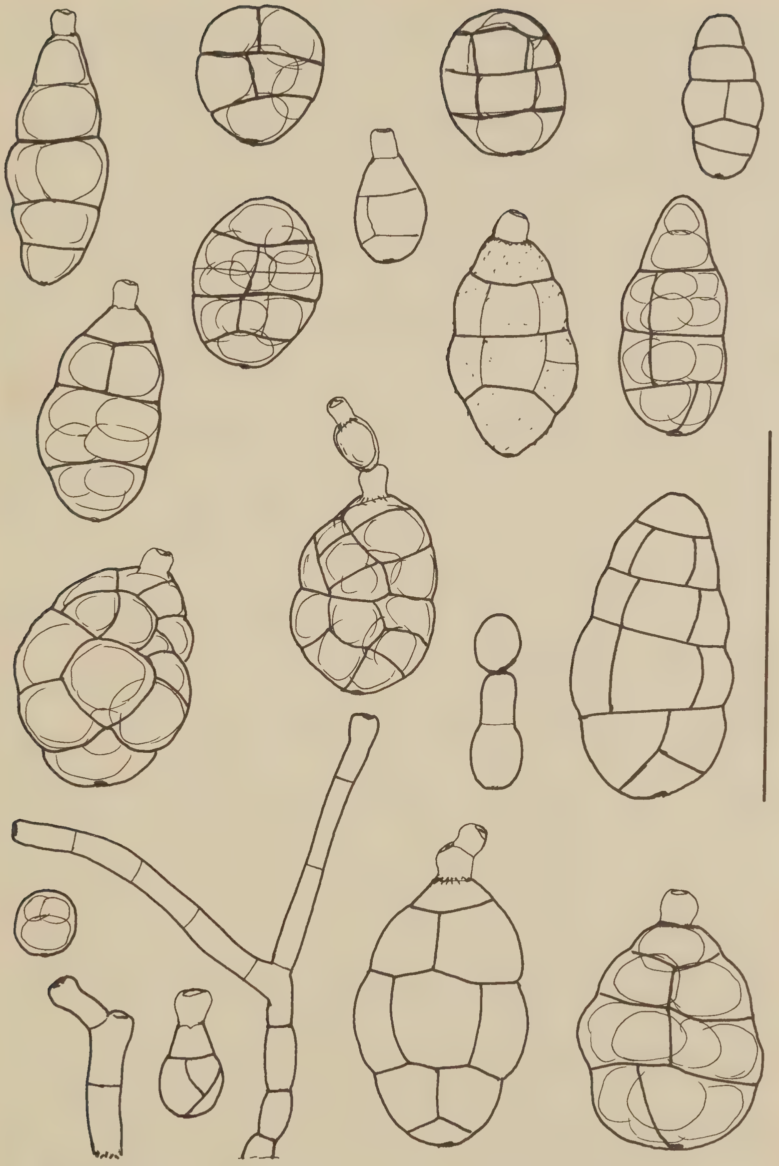

Fig. 42. Alternaria citri; conidia and conidiophores, ex Type. Magn.: vertical bar = 50μm.

The catalogued afflictions of citrus tree parts attributed to *Alternaria citri* might better be referred to by vernacular disease names, for purposes of reference and information content, than by the name of a putative single fungus incitant. Judging from scores of citricolous specimens labeled *A. citri* that I have examined from worldwide sources, perhaps 90% bear *Alternaria* species morphologically quite unlike *A. citri*; a few others are species of *Ulocladium* and *Stemphylium*; a tiny minority can be equated with *A. citri* with some degree of confidence. Black rot of oranges, rots of other citrus fruits, leaf spots, stem cankers -- all have been and still are being attributed to one fungus species; but the only relationship in most cases rests in the fact that the substrate is some part of a citrus plant and the fungus is phaeodictyoconidial. It currently is fashionable to lump miscellaneous, inadequately determined toxin-producing isolates together as "pathotypes" under early names of poorly understood species; this is little more than a bow to the editorial requirement that one's material be named, for it ignores the basic reason for using a name, which is to facilitate access to information in the taxonomic niche represented by the name.

Alternaria citri is best understood through N. B. Pierce's original description (1902) and type material (BPI, Jan. 1892, as *Macrosporium citri* E. & E.); by a long Bliss and Fawcett paper (1944) on the morphology and taxonomy of the species; and by details of illustration and description in M. B. Ellis and P. Holliday (1970).

Pierce (l.c.) had recognized a widespread internal *Alternaria* rot of navel orange in California groves for "eight or ten years" prior to 1902. At some time, presumably between January 1892 (the date on the type specimen) and March 22, 1902 (the date of publication of *A. citri*), Pierce sent material of blackened, infested orange-fruit tissue to J. B. Ellis. Part of this material, bearing a number 3602b, is in the Ellis Collection at NY; another portion, chosen as lectotype because it now is the better part of the specimen, is at BPI. Packets of both appear always to have been labeled "*Macrosporium Citri E. & E.*" and supposedly for this reason were discounted during searches for material of a citrus *Alternaria* studied by Pierce. There is no evidence that Ellis and Everhart published the name written on the packets or dealt further with the identity of Pierce's specimen. The material originated with Pierce, fits his published description and some of his manuscript drawings (published by Bliss and Fawcett, 1944), and presumably was examined by J. B. Ellis as well as by Pierce. The specimen has chronological and source characteristics of type material. The so-called "co-neotype specimens" of *A. citri*, prepared from cultures on Czapek agar and distributed to many herbaria by Bliss and Fawcett (e.g., **NY**, Bliss and Fawcett 2077, from *Citrus sinensis*, California, 1943; EGS 02-062) and the extensive "emended" type description published by them (1944) are of great value to an understanding of the species; but they have no nomenclatural standing or replacement value versus Pierce's original specimen and description.

A related opinion, agreeing with a suggestion made to me by M. B. Schol-Schwarz of the Centraalbureau voor Schimmelcultures, Baarn, more than 30 years ago, attaches to one of Fawcett's generally available and misleading isolates from citrus, his II no. 1229K (= **CBS** 107.27). This isolate is of an *Alternaria* species having little resemblance to *A. citri*; it is of the *A. tenuissima* group of species, which in nature usually produce unbranched or poorly branched chains of a few to many long-elliptical conidia that taper gradually into a narrow but not filiform beak and that often have a constricting median transverse septum that is darker than the other septa. This particular Fawcett isolate should not be used as a pattern for determination of *A. citri* isolates. (See sections 31 and 32 below: *Alternaria tenuissima* and *A. tenuissima* group, species 1.)

To return from this digression on spurious neotypes, unnecessary emendations, and misleading isolates, we find that Pierce, for whatever reasons, chose to describe his citrus fungus as an *Alternaria* species and to ascribe its authorship to "Ellis and Pierce" (Pierce, 1902). The name *Macrosporium citri* E. & E., though it is present on the type specimen associated with the Ellis Collection, has no nomenclatural standing.

The type description in Pierce includes remarks on conidium shape, dimensions, and septation: obovate, oblong-elliptical or subglobose, becoming short-clavate-oblong (to be read *ovate* and *obclavate* instead of *obovate* and *clavate* in order to interpret the belief commonly held by Ellis and many others of that period that conidia of such species are attached to the conidiophore by their narrowed end); 10-22 x 8-15µm in early stages, becoming 25-40 x 15-25µm, (3-)4-6 transversely septate, with one or more longitudinal septa in each transverse segment. The general picture is of broadly ovoid, muriformly septate conidia about 1.5 times as long as broad.

Pierce noted further that the terminal conidia "are oftener 3-6 catenulate in series" and that "as shown by cultures, secondary conidia often arise from the primary." It seems justified to infer that Pierce's observations on catenulation were based primarily or entirely on incubated or cultured specimens or isolates, because only about half of the conidia seen in his type specimen have secondary conidiophores or apical pores suggestive of secondary conidium production, which in itself suggests that chains in the initial material were seldom if ever more than two conidia in length. His remark that "secondary conidia often arise directly from the primary" may or may not mean that he considered the readily observed one-celled secondary conidiophores to be integral cells of their conidia rather than developmental chain-generating structures. In any case, and with a rare two-celled exception, all secondary conidiophores seen in his material are either a single short cell obviously distinct from cells of the spore body or, infrequently, a simple pore in the apical cell of the conidium.

Pierce concluded his characterization of *A. citri* with an observation that lifts a description potentially usable for determinations into a somewhat stricter diagnostic level: "The cells of the conidia at maturity incline to assume a spherical shape, and the conidia then resemble somewhat asci filled with globose sporidia." This is precisely the unusual aspect of conidia examined from the type specimen; it is a character readily noted in many conidia chosen for illustration from a "neotype" strain by Bliss and Fawcett (l.c., Fig. 1); and it is a feature of the photographed conidia in the right-hand half of the Ellis and Holliday illustration of the species (1970).

This impression of spherical cells within the larger conidia of *A. citri* derives from the fact that secondary septa, particularly longitudinal ones, appear to be ill-defined. The very pale septa delimiting an individual cell have pale secondary thickenings that enclose the colorless cell lumen. The three-dimensional layering of almost colorless structures within a pale brown conidium wall obscures the septum framework and gives an illusion of rounded inclusions lacking septal restraint. Most conidia in the type of *A. citri* show this character. The same character can be seen in conidia of comparable size in some other *Alternaria* collections from citrus sources, but it is absent from many other *Alternaria* specimens from similar sources.

Alternaria citri Ellis & Pierce, as described in Pierce and represented by his type specimen, is a distinguishable species within the context of citrus fruit rot *Alternaria* species and of isolates derived from such substrates (judging on the basis of the Bliss and Fawcett and the Ellis and Holliday illustrations cited above).

In brief, typical *A. citri* has pale brown, inconspicuously ornamented, broadly ovate, subovate, or oblong-elliptical, apically blunt, beakless conidia that commonly reach a size range of about 30-40 x 18-15µm; 1-3 of 1-4(-5) major transverse septa may be more strongly pigmented than secondary transverse and longitudinal septa; the few longitudinal and oblique septa in small to medium-size conidia may be strongly pigmented but often they and nearly all of the numerous longitudinal septa in larger conidia are pale and obscured by secondary wall thickening. Conidia of any age and size (1-celled to many-celled) may produce secondary conidia directly (but rarely) through an inconspicuous apical conidiogenous site or (commonly) by means of a short apical or lateral secondary conidiophore 1-2 cells in length.

The largest conidia in reference specimens known to me as preparations from living isolates of *A. citri* are more likely to be oblong-elliptical than broadly ovate and thus have greater length/width ratios (up to about 2.5) than the approximately 1.5 found for the type specimen. Conidia from culture very often are bluntly tapered apically, but they never have a discrete beak region; instead, every conidium in a chain of spores produces secondary conidia by means of a short, few-celled secondary conidiophore. One to three of the major transverse septa usually are markedly darker and more constricting than are secondary ones. The characters of ill-defined secondary septa and internal pale thickening of septum walls are at present considered to be usefully diagnostic in recognizing the species.

Type specimens of only two other of the 20 names (some illegitimate) published for ruticolous Dematiaceae suspected to be of the *Alternaria/Macrosporium* group contain fungi that can be identified as *A. citri*, namely, the *Alternaria* component of *Alternaria tenuis* Nees f. *chalaroides* P. A. Saccardo (but not the "f. *chalaroides*" component), and *Stemphylium citri* Patterson & Charles. All 20 published names are discussed in a concluding section below, following discussion of material identifiable with or mistaken for *A. citri*.

Only a few of the 90-100 specimens and isolates I have studied from ruticolous substrates are recognizable as *A. citri*. Representative specimens: **NY**, Bliss & Fawcett no. 2077, isolated from fruit of *Citrus sinensis*, California, 1943 (one portion of the so-called "co-neotype" prepared and distributed to several herbaria by H. S. Fawcett) (EGS 02-062); **NY**, N. B. Pierce, on oranges, California, 1892 (a portion of the lectotype of *A. citri* Ellis & Pierce; 3602b in the Ellis Collection, as *Macrosporium citri* E. & E.)

(EGS 03-019); **NY**, L. M. Underwood no. 2377a, on dead orange twigs, Florida, 1891 (as *Macrosporium*) (EGS 06-107); **BPI**, N. B. Pierce, on oranges, California, 1892 (lectotype; as *Macrosporium citri* E. & E.) (EGS 07-106); **BPI**, from oranges, Arizona, "Nov. 1907 or Dec. 1908" [sic] (permanent slide no. 1, as type of *Stemphylium citri* Patterson & Charles) (EGS 08-075); **DAOM**, E. T. Bartholomew no. 21, on lemon leaves (*Citrus limonia*), California, 1927 (as *Alternaria*) (EGS 09-087); **PAD**, in fruit of *Citrus deliciosus*, Italy, 1903 (as the *Alternaria* component of the type of *Alternaria tenuis* Nees f. *chalaroides* P. A. Saccardo) (EGS 11-123); **PAD**, in fruit of *Citrus deliciosus*, Italy, 1903 (the *Alternaria* component of an isotype of *A. tenuis* f. *chalaroides* P. A. Saccardo, in D. Saccardo, Mycotheca italica 1394) (EGS 11-124); **IMI** 104885, K. G. Pegg, on Washington navel orange, Australia, 1963 (ex culture) (EGS 23-050); **IMI** 77072, R. A. Christ, on orange, South Africa, 1959 (ex culture) (EGS 23-054).

In much of the herbarium and cultured material that has been available to me for study over the years, recognizable *A. citri* known from typical internal fruit rot and from citrus leaves and twigs seldom has been differentiated by name from other species of *Alternaria* or from *Ulocladium* and *Stemphylium* that occur on similar substrates.

A few observers have made the point that more than one phaeodictyoconidial species may be associated with citrus disorders such as rots, fruit and leaf spots, and twig infections. Doidge et al. (1953) recorded that fruit center rot and stem-end rot of orange were caused not only by *A. citri* but occasionally also by two other species of *Alternaria*. Doidge (1929) had made extensive comparisons of *Alternaria* isolates from leaves and fruits of lemon, orange, and tangerine and, whether or not she had among these a typical isolate of *A. citri*, was well convinced that the injuries she observed were caused by more than one species of *Alternaria*. Joly (1964, p. 158), commenting on alternarioid fungi he had seen from citrus sources, was of the opinion, with which I agree up to a point, that *Alternaria citri* is a name that denotes more a habitat than a species. In his treatment of the species, he suppressed the name *A. citri*, apportioned it "pro parte" between his concepts of *A. chartarum* Preuss and *A. tenuis* Auct., and later (1967) added species corresponding to his usage of *A. consortiale* (Thümen) Hughes and *A. tenuissima* (Fr.) Wiltshire as incitants.

Many pertinent isolates and specimens are of species suggested by Joly (1964, 1967), some of which now are treated as *Ulocladium*, with similarities to *U. atrum*

Preuss, *U. chartarum* (Preuss) Simmons, and *U. consortiale* (Thümen) Simmons; a few of these are discussed below. Only rarely have I seen citricolous material that I would refer to typical *A. alternata* (Fr.) Keissler, although a few isolates and specimens with similar characteristics can be held together as an *A. alternata* group until better segregations can be made with confidence. (It is appropriate to state here that the purpose of this discussion is to point out the several kinds of *Alternaria* that have been found and confused on citrus, not to revise definitively the taxonomy of a major portion of the genus solely on the basis of citrus-related specimens.)

Most of the *Alternaria* material known from citrus sources can be differentiated from *A. citri*, and some of it can be assigned at least to species-groups with established names.

Species of the *Alternaria alternata* Group

The *Alternaria alternata* group: species that produce abundantly branched (typical) or sparsely branched chains of numerous conidia in culture; the conidia, other than the initial few comparatively long ones at the base of chains of some species, are small (less than 30µm long) and have few (typically 1-4) transverse septa; chain generation is mostly by means of apical or lateral secondary conidiophores produced by conidia that otherwise seldom have a well-defined beak region.

29. **Alternaria alternata** (Nees : Fries) Keissler Fig. 43

I have encountered typical *A. alternata* only once among living isolates examined from citrus sources: IMI 254285, ex *Citrus aurantium*, India (EGS 34-020). In spite of apparent rarity on citrus substrates, the species characters need to be used as points of reference in identifying other species with long chains of comparatively small conidia.

Stable isolates of *A. alternata* grow readily and sporulate abundantly with little or no non-sporulating aerial mycelium (standard conditions given above); typically, individual erect conidiophores rise directly from the agar substrate and bear terminal clumps of conspicuously branched chains of conidia; approximately 50-70 conidia constitute the 4-8 branches of a fully developed head. The initial conidia produced directly from the conidiophore (right-hand half of figure), or within one to two conidia above it, tend to be ellipsoid, 5-7 transversely septate, and about 30-50 x 8-13µm; as the branching chains elongate, the more recently formed conidia (left-hand half of figure) are ellipsoid to ovoid, 3-5 transversely septate, and about 12-25 x 8-12µm. Juvenile conidia of the initial sporulation are narrowly ovoid with densely, minutely granulate walls; this dense ornamentation persists throughout the enlargement of these initial conidia, to such an extent that, when viewed in mounts under 125X magnification, their internal septa are obscured and the septation pattern indistinct; this punctulate ornamentation, the usual condition, sometimes may develop into a coarser verrucosity as conidia age. Juvenile conidia produced later in the chains are ovoid and also granulate, but not so much so that septa are obscured. Secondary conidiophores at the apex of conidia usually are 1-celled (2-4µm long), uncommonly extended geniculately to 15-20µm.

Key characters of typical *A. alternata* in culture: abundant sporulation; individual conidiophores arising directly from the substrate; bushy heads of long, well-branched chains of conidia; earliest conidia long-ellipsoid with dense ornamentation obscuring the septa; later conidia ovoid and also rough but not enough so as to obscure septa; secondary conidiophores of catenulate conidia mostly are 1-celled.

30. **Alternaria hesperidearum** (Pantanelli) E. Simmons, comb. nov. Fig. 44

(basionym *Macrosporium hesperidearum* Pantanelli, in Pantanelli and Cristofoletti, Staz. Sperim. Agrar. Ital. 46:641. 1913.) *In fructibus vivis Citri Aurantii, quos vexat (Campania).* Type: description and illustration, l.c., p. 641 and Tav. XIX, f. 9.

Several of the numerous isolates from citrus that have been available only as dried voucher specimens produce enormous numbers of dark, comparatively small, smooth or inconspicuously ornamented conidia in branching chains. The character combination of small size (conidia predominantly less than 25µm long) and smooth conidium wall is uncommon enough that, taking into account other characters, such isolates constitute a recognizable and segregatable species.

Pantanelli's description (l.c.) was of a fungus with conidiophores "*nodosae, articulis brevibus*" and with conidia "*pedicellum septatum, basi elatum atque incrassatum*"; with the help of his illustration (l.c.) and knowing that many mycologists of that period believed that the narrowed end of detached *Macrosporium/Alternaria* conidia had been

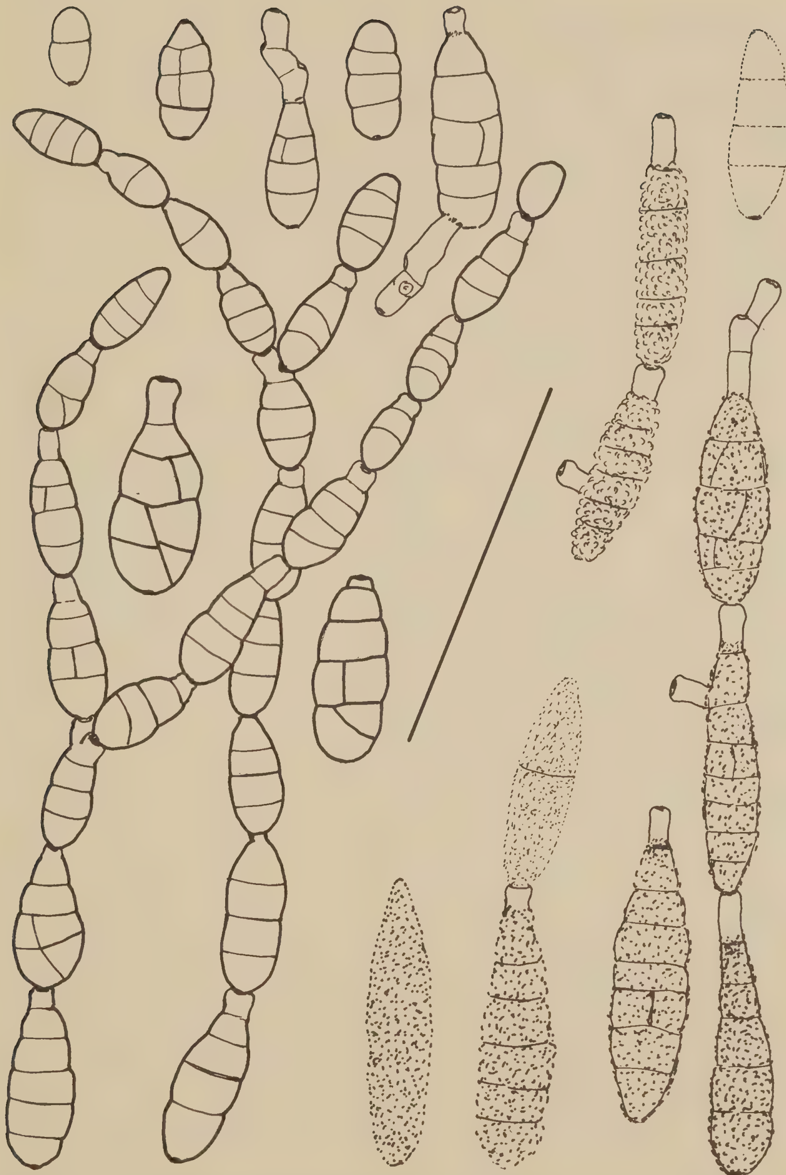

Fig. 43. Alternaria alternata; characteristic conidia and pattern of branching chains, ex EGS 35-056. Magn.: oblique bar = 50um.

the original point of attachment to a conidiophore, these significant attributes can be interpreted as conidiophores with short segments between geniculate swellings (i.e., conidiophores with multiple secondary extensions and sporulation sites) and conidia with a septate apical extension that is swollen at the tip (i.e., conidia with apex converted into a secondary conidiophore). These characters plus Pantanelli's observations that conidia are small (20-26 x 12-16μm), muriseptate, dark brown, and smooth define the species, which had as type habitat living fruits of *Citrus aurantius*.

In culture, conidiophores of *Alternaria hesperidearum* readily produce secondary geniculate growth and sporulation sites. Conidia also produce secondary conidiophores with solitary or multiple sporulation sites abundantly. The first conidia produced on a conidiophore, as is true in general for species of the *A. alternata* group, tend to be longer and more septate than are conidia produced later in a chain; these primary conidia usually produce a second conidium apically by means of a short 1-celled secondary conidiophore. Conidia produced subsequently are comparatively small in size at the stage when they initiate secondary conidiophores and subsequent chain formation. The pattern of conidiophores with multiple sporulation sites and of large numbers of small, smooth conidia generating branching chains of similar conidia by means of abundant short secondary conidiophores yields in culture a dense, almost powdery aggregation of spores.

Alternaria hesperidearum primary conidiophores commonly are about 50-60 x 3-4μm with 1-4 geniculations and their associated sporulation sites; primary conidia are obclavate and at most about 30-35 x 9-12μm with 5-6 transverse and 1-2 longitudinal septa at the time they initiate apical secondary conidiophores; most secondary conidia are broadly ellipsoid or ovoid and about 18-20 x 7-9μm with 1-3 transverse and 1-2 longitudinal or oblique septa when they initiate secondary conidiophores. Almost all conidia are smooth (a small percentage of them are inconspicuously punctate rough, rarely definitely verrucose), chestnut brown (except for paler secondary conidiophore extensions), with well-defined septa of which 1-3 transverse ones often are thicker and darker than the others (but not embellisioid), and with one or frequently two apical, lateral or basal secondary conidiophores.

Specimens of *A. hesperidearum* include IMI 104879, from *Citrus nobilis*, Pegg 2097, Australia, 1962 (EGS 23-034); IMI 104883, from *Citrus limon*, Pegg 15481, Calif., USA, 1963 (EGS 23-027); IMI 116088, from *Citrus aurantium*,

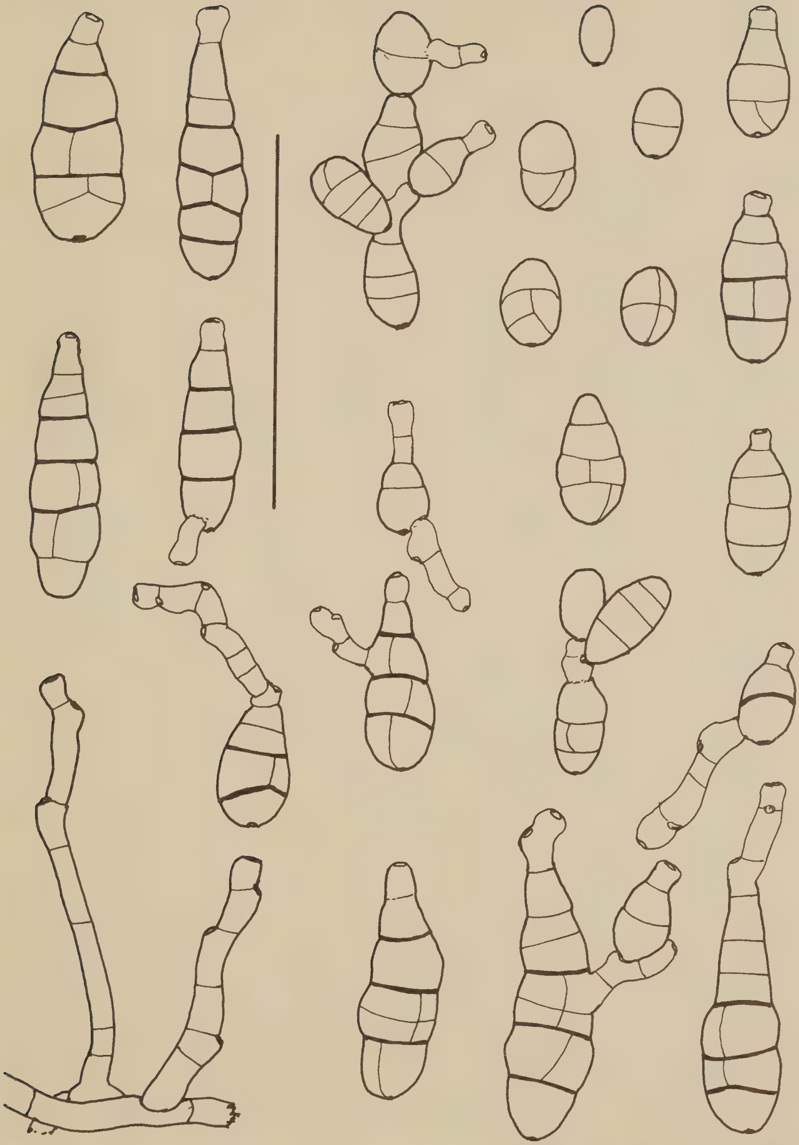

Fig. 44. Alternaria hesperidearum; characteristic conidia and conidiophores, ex IMI 104883. Magn.: vertical bar = 50µm.

Zyngas 486, Cyprus, comm. 1965 (EGS 23-048); IMI 120371, from *Citrus* sp., Laundon 779, New Zealand, 1966 (EGS 23-041).

31. *Alternaria alternata* group; species 1. Fig. 45

Alternaria hesperidearum has been segregated above as an infrequently encountered species that characteristically produces large numbers of small, smooth-walled conidia. A rough-walled analogue species, or group of species, is of common occurence among isolates from a great many different plants, soil debris, and other miscellaneous substrates. No valid name of the 19th century seems to be usable for such isolates examined from citrus sources; there are several 20th century names competing within the morphological diversity of this group of species, but I see no overall advantage at present in choosing one for citrus material before sorting out those for material from other sources.

An excellent representative of this species came to hand in July 1989 when I cut open a navel orange purchased at a local market (original source probably California). The exterior of the fruit was unblemished; the interior was filled with blackened tissue, the cut surface of which (in a damp chamber) became covered with masses of conidia newly produced within the space of a few hours. Single-conidium isolates were obtained readily (EGS 39-090).

A general description of this species is very similar to that of *A. hesperidearum*, except for differences in external ornamentation of conidia. Specifically, primary conidiophores are simple with 4-5 geniculate sporulation sites, or variously branched with a few to many sporulation sites in the upper half of each branch, the major branches about 50-80 x 3-4µm; primary conidia are ellipsoid or ovoid and at most about 30 x 12µm with 4-6 transverse and 2-3 longitudinal septa; secondary conidiophores apical or lateral from primary conidia have 3-5 geniculate conidiogenous extensions; secondary conidia usually are broadly ellipsoid or ovoid and 12-20 x 7-8µm with 1-3 transverse and 0-2 longitudinal or oblique septa when they initiate short, sometimes 1-2 geniculate secondary conidiophores. Almost all conidia are conspicuously punctate rough to verrucose (only a small percentage appear smooth), chestnut brown (except for paler secondary conidiophores), with well-defined septa of which 1-3 transverse often are slightly thicker and darker than the others. The overall appearance is of a closely branched system of secondary conidiophores and short chains of conidia borne on a loosely branched

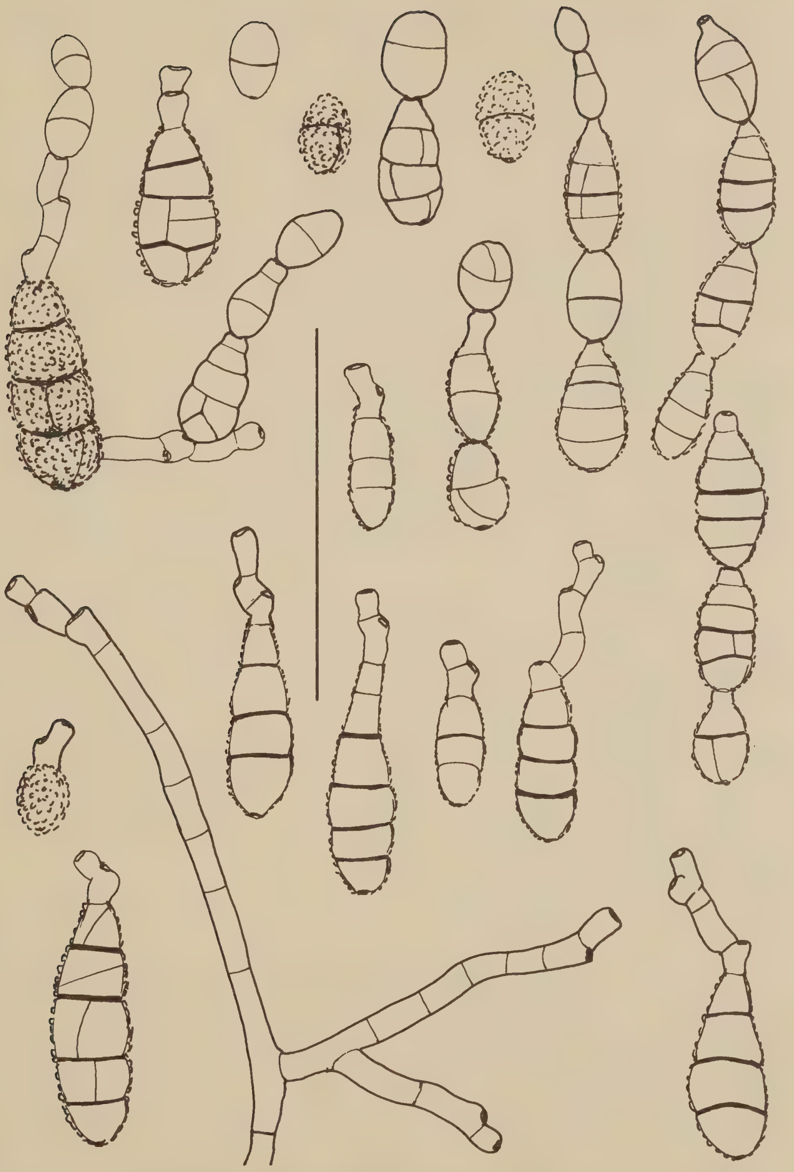

Fig. 45. Alternaria alternata group, species 1; characteristic conidia and conidiophores, ex culture EGS 39-090. Magn.: vertical bar = 50µm.

aerial system of primary conidiophores and of primary conidia bearing abundantly-conidiogenous secondary conidiophores.

Species of the *Alternaria tenuissima* Group

The *Alternaria tenuissima* group: species that in nature usually produce unbranched or sparsely branched chains of a few to many long-elliptical conidia that taper gradually into a narrow but not filiform beak and that often have a median transverse septum that is darker and more constricting than are other septa. Conidia of typical *A. tenuissima* (Nees & T. Nees : Fries) Wiltshire, at maximum development in size and septation in nature, reach a size range of 60-75 x 12-16(-20)µm and have 7-10 transverse (the median darker and thicker than others) and 1-2 longitudinal septa in some of the broader transverse segments. In culture (Fig. 46, left), when chain generation is rapid, the narrowed beak often is lacking; instead, the ellipsoid to broadly ovoid spore body terminates abruptly apically in a short secondary conidiophore, which supports subsequent chain formation.

I have not seen typical *A. tenuissima* among the citrus material studied. However, species of the *A. tenuissima* group are encountered very commonly in nature, so it is not surprising to have found at least two group species other than the type among the citrus specimens and isolates. As this group figures largely in the descriptive literature of the late 19th and early 20th centuries, and continues to be under review, it is premature to designate old names or devise new ones for the noteworthy but at present questionably unique material derived from a single host/substrate genus or family.

32. *Alternaria tenuissima* group; species 1. Fig. 46

H. S. Fawcett (1926) was studying the relationship between *Alternaria* and disease in the navel orange (*Citrus sinensis*) in California about 20 years before Bliss and Fawcett (1944) published their observations on the morphology and taxonomy of *A. citri*. Some of Fawcett's isolates dating from the early period were sent to the Centraalbureau voor Schimmelcultures in 1927; one of these (Fawcett II no. 1229K) has been conserved and studied at CBS and elsewhere (CBS 107.27 = QM 1736 = EGS 06-187 = ATCC 24463).

Although this early Fawcett isolate seems always to have been refered to as *A. citri*, and presumably has influenced some interpretations of that species, it is quite

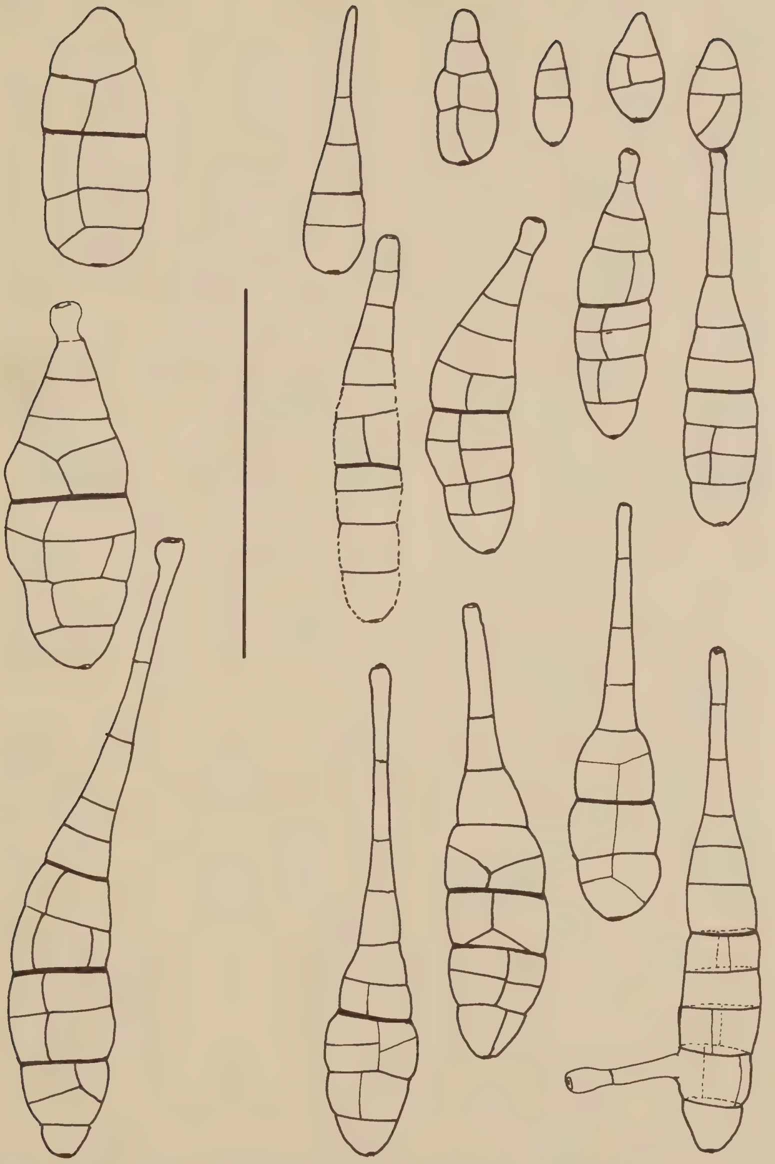

Fig. 46. Left, Alternaria tenuissima, conidia ex representative culture, EGS 37-116; right, A. tenuissima grp., sp. 1, ex cult. EGS 06-187. Magn.: vertical bar = 50µm.

unlike the type of *A. citri* as well as the isolate discussed so extensively as representative of the species by Bliss and Fawcett (1944).

This Fawcett isolate of *Alternaria* (from *Citrus aurantium*) resembles *A. tenuissima* in that many conidia of its long chains are long-ellipsoid and have a long tapering beak and a prominent median septum. It differs from typical *A. tenuissima*, when compared in culture on V-8 agar, in that a high percentage of *A. tenuissima* conidia fail to produce a tapering apical beak and remain broadly ovoid with or without a short apical secondary conidiophore, whereas a high percentage of the smaller and narrower conidia of the Fawcett isolate are conspicuous in the production of long, slender true beaks.

This Fawcett isolate produces long chains of 10-15 conidia that are elongate and long beaked near the base of the chain (30-40 x 11-13μm + 25-30 x 2-3μm; total length about 55-65μm) but that are comparatively small, ovoid and beakless or short beaked beyond the middle of the chain (15-27 x 8-12μm).

33. *Alternaria tenuissima* group; species 2. Fig. 47

Another species with group similarity to *A. tenuissima* is represented well by a specimen on leaves of *Citrus sinensis* collected in Cyprus by R. M. Nattrass in 1933: IMI 1239 (EGS 22-089).

This Nattrass specimen appears to have produced conidia in short chains in nature, as *A. tenuissima* also often does; the largest conidia of both species are similar in size and septation. However, the typical patterns of conidium development and enlargement are different. In typical *A. tenuissima* the narrowly tapered beak, when present, usually originates as a distinct apical extension of juvenile conidia; it lengthens as the spore body enlarges. Juvenile conidia of the Nattrass specimen have a conical or broadly wedge-shaped apical cell that lengthens and widens into a broad, blunt beak and eventually into a rather sturdy true beak or an apically swollen secondary conidiophore. Juvenile conidia of the Nattrass material, at the stage of 3-5 transverse septa, are 25-35 x 8-13μm, sometimes with a longitudinal septum in one or two of the transverse divisions; fully developed conidia with a beak tipped with a conidium-generating cell are broadly ovoid, 50-60 x 18-20μm, (with 6-7 transverse and 5-7 longitudinal septa), or with a fully extended true beak they are long-ellipsoid, 70-90 x 16-18μm (with 8-9 transverse and 5-7 longitudinal septa). The largest conidia of both types are

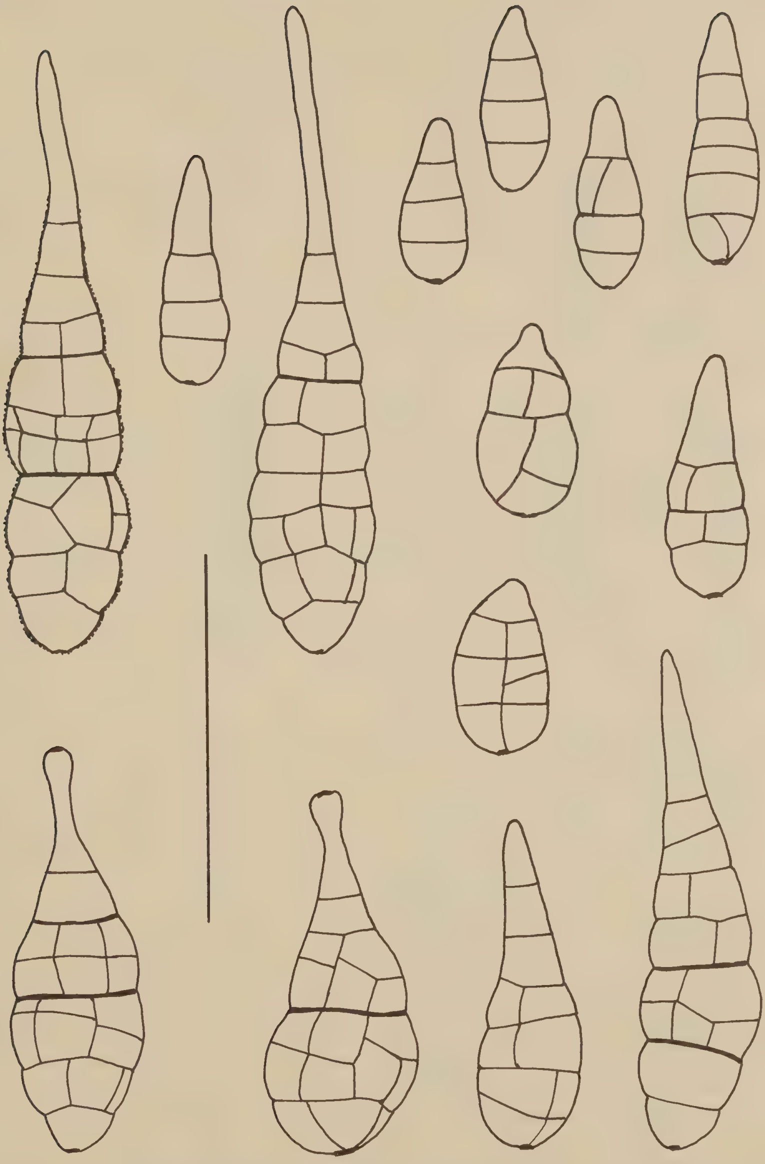

Fig. 47. Alternaria tenuissima grp., sp. 2; conidia, ex specimen IMI 1239. Magn.: vertical bar = 50μm.

moderately constricted by one to three of the transverse septa; the walls of some are punctulately ornamented.

A New *Alternaria* Species on Satsuma Orange

34. **Alternaria pellucida** E. Simmons, sp. nov.

Two isolates from fruit and a leaf of *Citrus unshiu* Markovich (Satsuma orange) represent an *Alternaria* species unlike any other known to me not only from citrus materials but also, I believe, from any other source.

Alternaria pellucida E. Simmons, sp. nov. Fig. 48
(Etym.: L. *pellucida*, refering to conidium character)

Ex culturis in agaris V-8 descripta. Conidiophora simplicia vel ramosa, plerumque geniculis conidiogenis duobus vel pluribus, ramis 60-75 x 3-4µm. Conidia ovoidea vel longiellipsoidea, erostrata, brevipseudorostratescentia, pallide fulva, punctulate aspera, pellucida, maturitate 40-55 x 10-12µm, 6-8 transverse et 0-2 longitudine septata. Sporulatio in catenis simplicibus conidiorum 8-10. Habitatio typi in fructu Citrus unshiu Markovich, Japan. Typus: partes ex EGS 29-028 (ex isol. K. Tubaki 4305-7-1) desiccatae et in BPI (holotypus) et pro isotypus saltem in IMI et NY conservandae.

Conidiophores arise directly from the agar substrate surface or often from aerial hyphae; they are simple or branched, usually with two or more conidiogenous loci; individual branches reach 60-75 x 3-4µm. Ovoid to long-ellipsoid, pale tan conidia are produced in moderately long chains in culture (up to 8-10) and are fairly uniform in size at fullest development, being about 40-55 x 10-12µm; secondary conidiophore beaks usually consist of a single cell that is paler than the spore body. Conidia have as many as 6-8 transverse and 0-2 longitudinal septa; the initial median septum often is darker and thicker than any of the other septa, but the entire internal septum pattern is somewhat obscured by the dense and minutely punctulate ornamentation of the conidium wall. With few exceptions, the conidia are translucent but not transparent.

The only examples of this species known to me are the two original isolates: EGS 29-028, isol. 1968 or earlier from fruit of *Citrus unshiu*, Japan, K. Tubaki 4305-7-1 (source of type specimen); and EGS 29-050, isol. 1968 or earlier from leaf of *C. unshiu*, Japan, K. Tubaki 4310-25-1.

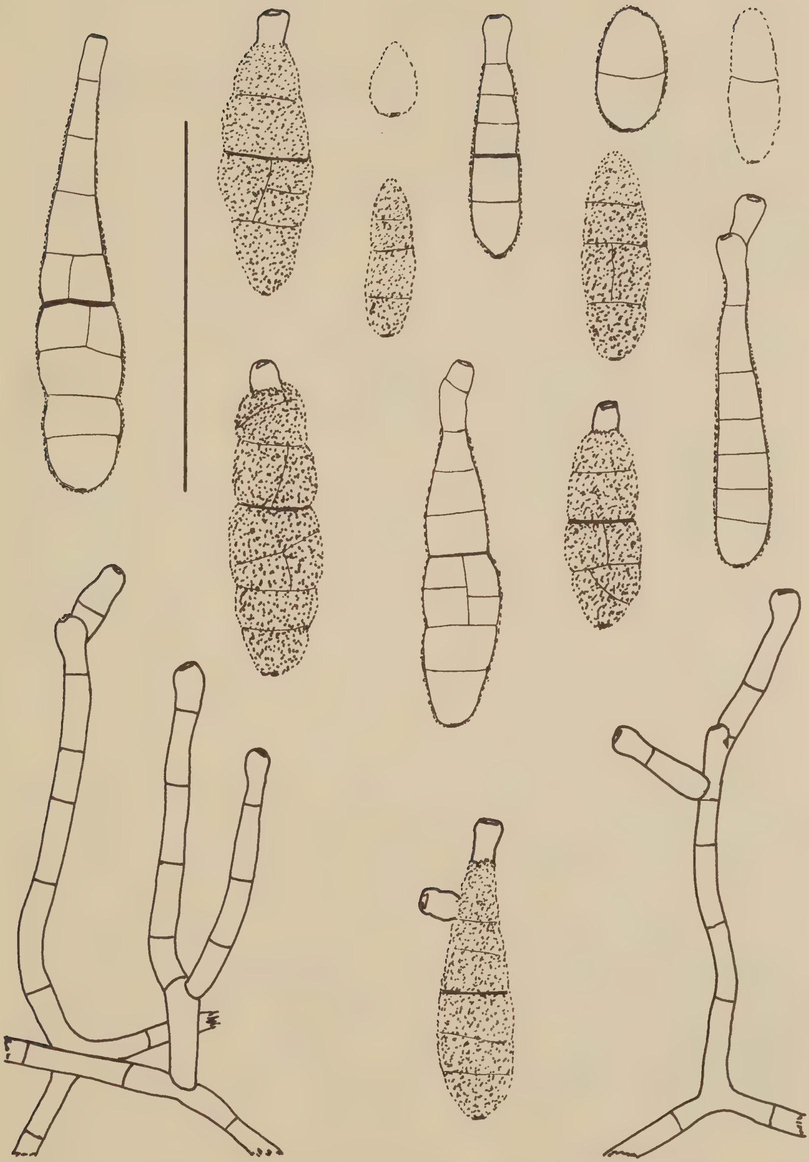

Fig. 48. Alternaria pellucida; typical conidia, ex Type. Magn.: vertical bar = 50µm.

Ulocladium Species on Citrus

Species of *Ulocladium* Preuss known to me from citrus sources are similar to but not identical with either *U. botrytis* Preuss or *U. atrum* Preuss (see Simmons 1967, key and illustrations).

One of these, isolated from *Citrus sinensis* in South Africa, can be identified to genus but not to species on the basis of an existing dried culture voucher specimen: IMI 1410, ex navel orange, Wager 2435, South Africa (EGS 21-100).

A second species is of the *U. atrum* group: EGS 30-188, isol. Jan. 1973 or earlier from *Citrus* sp., R. T. Hanlin 5612, Georgia, U.S.A. It probably will prove possible to accommodate this isolate in *U. atrum*, although its conidia are larger on the average and its conidium ornamentation and pigmentation are less nearly opaque than is typical of *U. atrum*.

A third species with some similarity to *U. botrytis* is known from dried voucher specimens that originated from isolates made in California and in Iraq: BPI (as *Stemphylium* sp.), from *Citrus* sp. (lemon), July 1923, C. O. Smith, California (EGS 20-057); and IMI 207185, from branch or leaf of *Citrus* tree, Sept. 1976 or earlier, K. K. Al-Hassan, Iraq (EGS 34-137). The conidia are distinctive enough that the species can be described as novel.

35. **Ulocladium obovoideum** E. Simmons, sp. nov. Fig. 49

Ex cultura sicca descripta. Conidiophora copiosa, curvata, simplicia vel raro ramosa, ex lateribus hypharum oriunda, cylindrica vel nodulosogeniculata, fulva, septata, ad 100 x 5µm, plerumque ad genicula 9 conidiogena. Conidia initio obovoidea vel ellipsoidea, helvola, laevia, postea late obovoidea, castanea, uniformiter punctulate aspera, basaliter apiculata, 23-28 x 14-18µm; plerumque septa unico principali transverso tum saepe septis secondariis obliquis vel transversis 1-2 (raro 3), septis longitudinalibus 1-2; conidia solitaria aut raro conidiophoro secundario. Habitatio typi: Citrus limon (L.) N. L. Burm. Holotypus: BPI *cultura sicca, July 1923, C. O. Smith, California, U.S.A.*

Conidiophores of *U. obovoideum* in culture are abundant, becoming curved or contorted due to successive apical geniculate production of conidiogenous cells, medium golden brown, up to 100 x 5µm. Juvenile conidia are medium yellow brown, smooth or sparsely punctulate, obovoid or broadly ellipsoid, with a single median transverse septum, 1-2

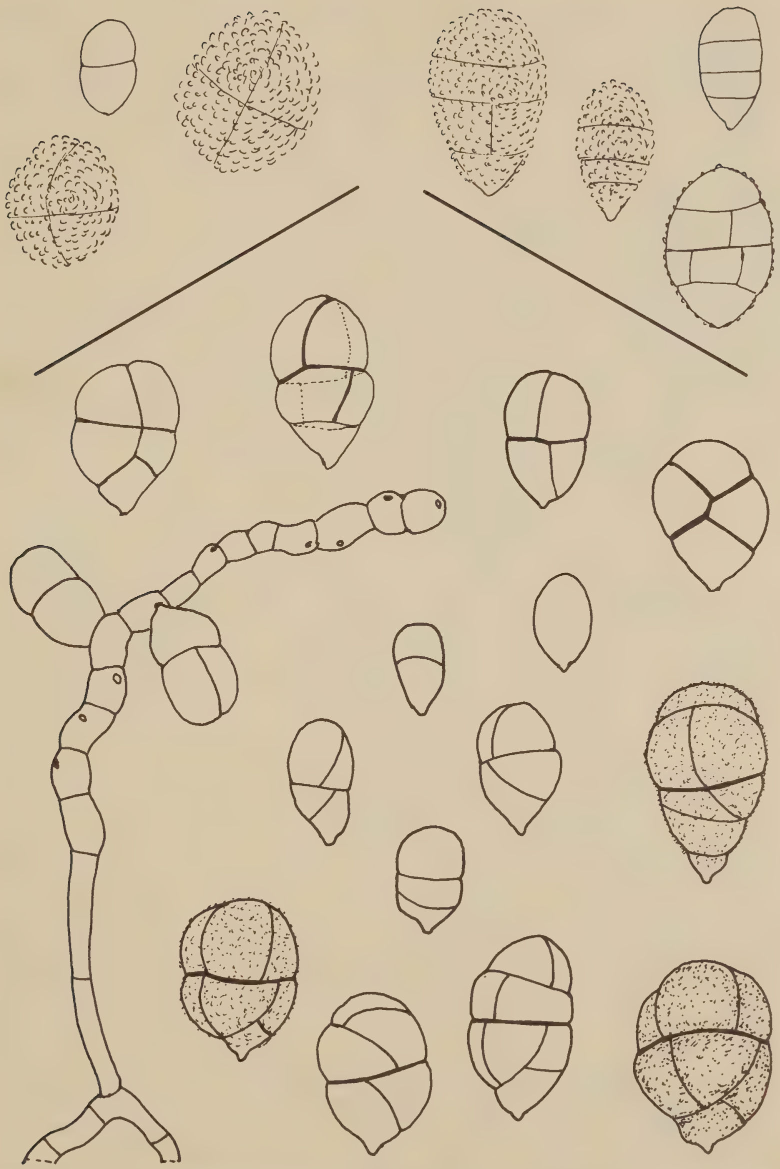

Fig. 49. Ulocladium spp., conidia ex culture; upper left, U. atrum (EGS 30-191); upper right, U. botrytis (EGS 13-030); below, U. obovoideum, ex Type. Magn.: oblique bar = 50μm.

oblique or longitudinal septa, and a distinctly apiculate base when they are about 18-21 x 10-13µm; conidia later become broadly obovoid with a conspicuously pointed base, dark chestnut, uniformly minutely and closely punctulate roughened, 23-28 x 14-18µm, usually with a single prominent median transverse, slightly constricting septum, sometimes with an additional transverse or oblique septum, uncommonly with a third or fourth additional transverse or oblique septum, and 1-3 longitudinal septa. Conidia nearly always are solitary; rarely a conidium will produce a secondary geniculate conidiophore.

The conidium wall ornamentation of *U. obovoideum* is so fine that the conidia appear to be smooth when examined at a magnification of only 125X; conidia usually have a single prominent transverse septum (plus oblique ones). In contrast, the conidium wall ornamentation of *U. botrytis* is uniformly granulate to verrucose, easily visible at 125X; fully developed conidia usually have 3 transverse septa.

Stemphylium Species on Citrus

Typical *Stemphylium* material apparently has not been collected often on citrus. Only one *Stemphylium* species definitely has been described from citrus lesions, namely, *Macrosporium rosarium* Penzig on leaves of *C. limon*. One *Stemphylium* specimen from lemon fruit also has been seen.

Stemphylium botryosum Wallroth Fig. 50

The single specimen I have seen that can be identified with *S. botryosum* is a U.S. Department of Agriculture intercept that originated in Spain: **BPI**, on fruit of *Citrus limon* from Spain, intercepted Feb. 1962 at New Orleans, det. A. J. Watson (EGS 20-081). Abundant conidia reach a maximum size of about 30 x 20-25µm. The conidia of this specimen are darker and less densely ornamented than are those of typical *S. botryosum* from other sources; otherwise the identity is acceptable (see Simmons, 1967 and 1986b).

36. **Stemphylium rosarium** (Penzig) E. Simmons, comb. nov.

(basionym *Macrosporium rosarium* Penzig, Funghi Agrumicoli, p. 95, 1882.) Holotype: **ROPV**, [on dead area of leaf of *Citrus limonum*], S. Terenzo 1878, leg. G. Gibelli (EGS 12-009). Fig. 50

Penzig described and illustrated (l.c., Fig. 1208) a typical *Stemphylium* with conidiophores consisting of 8-12

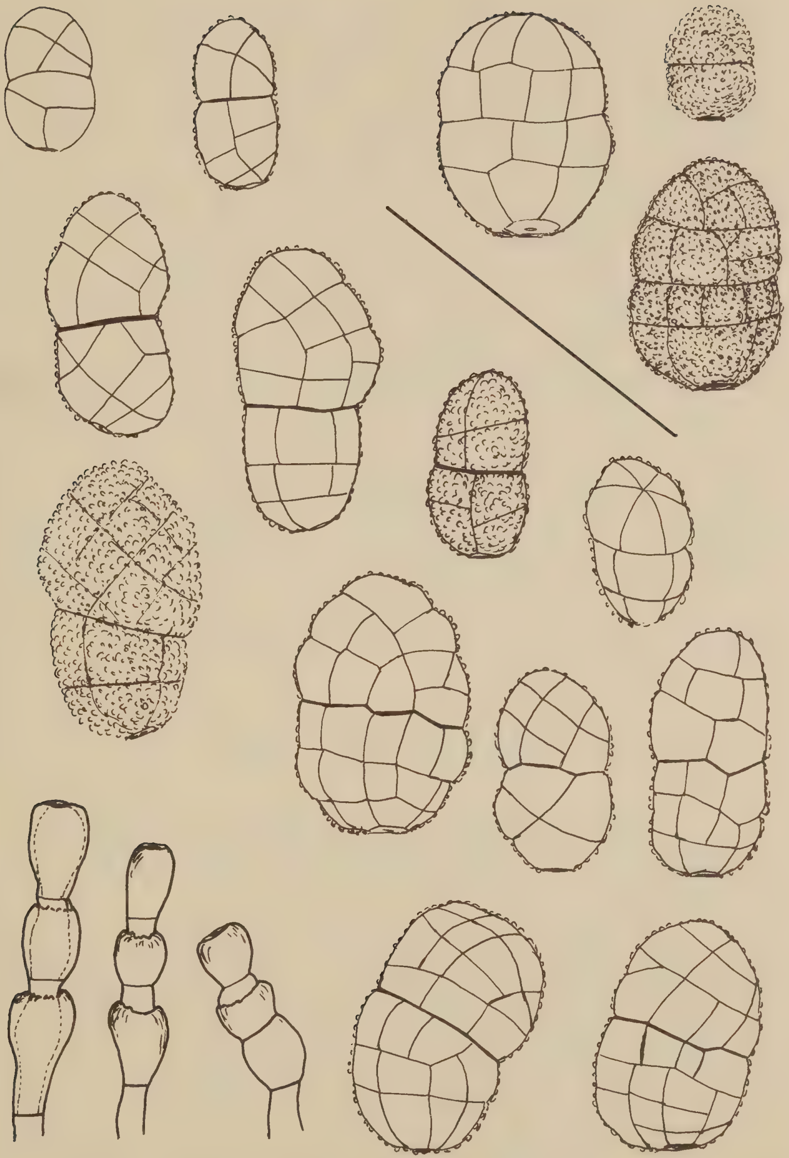

Fig. 50. Stemphylium spp.; upper right, S. botryosum, characteristic conidia; remainder, S. rosarium, conidia and conidiophores, ex Type. Magn.: oblique bar = 50µm.

1-celled, swollen proliferations (these, presumably, rosary-like in appearance). He gave the conidiophores as 52-90 x 5-9μm (abundant remaining fragments often are 50μm or more long). Conidia were described as variable in form and size, more or less constricted at the septa, granulose-echinulate, olivaceous, becoming darker, 25-36 x 18-25μm. All of this fits the type specimen well (a few conidia reach a length of 40μm), even though the description can scarcely be considered definitive.

The pattern of conidium septation probably is the most remarkable character of this species. Juvenile conidia past the stage of one or two transverse septa usually lay down additional septa with an oblique orientation, in the upper half of the conidium only, or in the lower half, or in both concurrently. Subsequent secondary septum formation continues and accentuates the angled pattern.

Stemphylium rosarium conidia are similar in maximum size to those of *S. botryosum*. However, conidia of *S. rosarium* are not so densely ornamented as to obscure their internal septa; also the pattern of septation typically is influenced by the presence of prominently oblique septa, resulting in the skewed cellular appearance of many conidia. Conidia of *S. botryosum*, in contrast, are so densely ornamented that internal septa often are difficult to see; also their pattern of septation typically appears rectangular in natural specimens.

Chronological Overview of Names Attributed to Taxa Described from Rutaceae

37. **1877** *Macrosporium ruticola* Thümen ['*rutaecolum*'] in Bolle and Thümen, Boll. Soc. Adriat. Sci. Natur. Trieste 3: 432. *In fructibus maturis Rutae graveolentis Lin. Gorizia.*

I have been unsuccessful in attempts to locate the type specimen of this species. The type description, including conidium dimensions of 35-40 x 20μm, is too generalized to be useful in the absence of a specimen. An associated illustration (l.c., p. 463-464, Tav. I, fig. 28.) could represent an *Alternaria* species if the broadly clavate conidia were repositioned to be obclavate (commonly necessary in interpreting the concept of "*Macrosporium*" of that time). The species is considered to be unknowable on the basis of presently available evidence.

38. **1882** *Alternaria brassicae* (Berk.) Sacc. f. *citri* Penzig

Funghi Agrumicoli, p. 92. *Hab. in petalis staminibus Citri Aurantii L., in frigidariis, Strà (prope Patavium), Febr. 1882 legi O. Penzig.*

Penzig's manuscript specimen at **ROPV** (EGS 12-007) logically should be the holotype of the form. However, what appeared to be fungus growth scattered on petals, stamens and pistil of a citrus flower bud failed to yield conidia similar to those illustrated by Penzig (l.c., fig. 1206). The type description, including conidium dimensions of 60-70 x 14-18µm, and illustration of long-ellipsoid conidia with 8-10 transverse septa and 1-2 longitudinal septa in 3-4 of the transverse segments, suggest an *Alternaria* species of the *A. tenuissima* group. No firmer opinion is possible, other than that this fungus has little resemblance to *A. brassicae*, whose conidia often range to 300 x 30µm in size.

. **1882 *Macrosporium rosarium* Penzig
Funghi Agrumicoli, p. 95. *Hab. in maculis aridis foliorum Citri Limonum, S. Terenzo 1878 (leg. G. Gibelli).* Holotype: **ROPV**, S. Terenzo 1878, leg. G. Gibelli; O. Penzig (EGS 12-009).

= *Stemphylium rosarium* (Penzig) E. Simmons; ** See section 35 above.

39. **1882** *Alternaria tenuis* Nees f. *prolifera* Penzig
Funghi Agrumicoli, p. 94. *In foliis Citri Limonum, semel in Horto Patavino reperta.*

Penzig's description and illustration (l.c., fig. 1204C) are of conidia (similar to those of *A. tenuis* Nees = *A. alternata* (Fr.) Keissler) lying on the surface of a lemon leaf and germinating in place. Individual conidia are described and illustrated with two, three, and finally as many as six apical, sub-basal, or lateral rostra, perfectly drawn as typical, short secondary conidiophores, two of which are shown producing secondary conidia.

The forma is a germination phenomenon, not a taxonomic entity; it can be treated, if anyone should consider it necessary, as a synonym of *A. alternata*.

40. **1887** *Alternaria brassicae* (Berk.) Sacc. f. *citri* Pass.

Listed thus by A.-B. Langlois (1887, p. 27) in his catalogue of plants of lower Louisiana, U.S.A., in a list of *Alternaria* species, but without comment or data of any sort. There is no evidence that Passerini ever published this name. The reference presumably is to *A. brassicae* f. *citri* Penzig. See section 38 above.

41. **1887** *Stemphylium macrosporoideum* (Berk.) Sacc. var. *spumarioides* Penzig

Annali di Agric., no. 116, p. 413. *Hab. in trunco vetusto Citri vulgaris, Romae (S. Pietro in Vincoli, jan. 1886, ipse legi).* Holotype: ROPV, in trunco vetusto Citri vulgaris, etc. (EGS 10-009).

Penzig's description, specimen, and illustration (l.c., t. 44, f. 5) are of a species of *Monodictys* cfr. *M. glauca* (Cooke & Harkness) Hughes, with conidium maximum size about 15-20µm diam., mostly smooth, or a few rough.

42. **1899** *Macrosporium citri* McAlpine

Fungus Diseases of Citrus Trees in Australia, and Their Treatment, p. 91. *On leaves of Lemon. June. South Australia (Molineux).* Holotype: VPRI, leaves of *Citrus limonum*, South Australia, July [sic] 1896, Molineux (EGS 09-145).

McAlpine described three species of *Macrosporium* from citrus substrates. I believe that, of the three, only *M. citri* is likely to be recognized in modern times on the basis of the original description, illustration, and specimen.

McAlpine described and illustrated (l.c., Pl. XXI, fig. 69) what can be interpreted as an *Alternaria* with long ovoid, ellipsoid or obclavate conidia gradually tapered to a blunt or slightly extended (to 15µm long) apex; conidia have as many as six constricting transverse and a few longitudinal or oblique septa and are as large as 60 x 20µm; conidia were described as smooth and non-catenulate.

The specimen fragment I have been able to examine is practically devoid of visible fungus spore elements. A single *Alternaria* conidium that fits the McAlpine description was found; it resembles conidia of *A. citri* Ellis & Pierce except that its dimensions, 60 x 25µm, are greater than any known to me from either typical or cultivated material of *A. citri* (max. about 45 x 22µm). Wiltshire examined this or another portion of the type in 1934 at IMI and returned the specimen to Australia with a photograph of his drawings of conidia and conidiophores, which I have seen. Maximum dimensions of conidia in his drawings (50-60 x 25µm) are close to those of my limited observations.

The pattern of conidium septation in the type of *M. citri* is more complex and the number of cells greater than are those of *A. citri* Ellis & Pierce. Although McAlpine saw no catenate conidia and Wiltshire did not draw an apical pore or scar on the apical cell of any conidium, a short but distinct secondary conidiophore is present on the conidium I have seen and the apex of a few of the conidia in Wiltshire's drawings look suspiciously conidiophoric.

No other species from citrus sources has exactly the characteristics of *M. citri*, even though it is so poorly represented by its original specimen fragments. I wish to refrain from synonymizing the name with *A. citri* Ellis & Pierce, from which it differs primarily in conidium dimensions.

Alternaria macalpinei E. Simmons, nom. nov.

(replaced synonym: *Macrosporium citri* McAlpine, Fungus Diseases of Citrus Trees in Australia, and Their Treatment, p. 91. 1899; the original epithet cannot now be combined legitimately with *Alternaria* because of the prior legitimacy of *Alternaria citri* Ellis & Pierce.)

43. 1899 *Macrosporium disruptum* McAlpine

Fungus Diseases of Citrus Trees in Australia, and Their Treatment, p. 92. *On green leaves of orange. March, 1899. Burnley, near Melbourne.*

McAlpine described as a new species and illustrated (l.c., Pl. XXI, fig. 70-72) a fungal growth with a "Cladosporium-stage" and a "Macrosporium-stage." The single muriformly septate conidium illustrated (l.c., fig. 72) is obclavate, with 7 transverse and 3 longitudinal septa, and 47 x 15µm in size. Neither the illustration nor the description presents a unique character; I have been unable to locate a type or other pertinent specimen at NSW, MEL, or elsewhere. The *Macrosporium* (possibly = *Alternaria*) component of the presumed mixture is unidentifiable in these circumstances.

**. 1902 *Alternaria citri* Ellis & Pierce

in Pierce, Bot. Gaz. 33:234. *In oranges in California.* Lectotype: BPI, *Macrosporium citri* E. & E., on (Oranges) *Citrus* sp., California, Jan. 1892, Newton B. Pierce, ex Herb. Ellis (EGS 07-106).

This is a legitimate name, correctly applicable only to material identifiable with its type. It has been demonstrated that the morphology of this fungus is widely misunderstood, with the result that a high percentage of available voucher specimens and cultures have been misidentified and that, as a consequence, information attributed to a citrus/*A. citri* relationship is more likely to have been misapplied in the past than not. **See section 28 for a more extensive discussion of this species.

44. 1902 *Macrosporium internum* McAlpine
Proc. Linn. Soc. New South Wales 27: 375. *Sydney, N.S.W., C. French, Junr.; on Mandarin Oranges; Sept. 1900.*

McAlpine's (l.c.) description is of a fungus found associated with an internal black rot of fruit that externally appeared to be sound. There are no illustrations in the publication; I have not been able to find type or other pertinent specimens at **NSW**, **MEL**, or elsewhere.

If the fungus is an *Alternaria*, which seems a logical assumption from McAlpine's concept of *Macrosporium* (see above), then this species (interpreting McAlpine) has amber to olivaceous, obclavate, beaked conidia that are more or less constricted at 5-8 transverse septa; one or two longitudinal septa occur in each transverse segment; the conidia are 37-75 x 17-20µm.

This description has very little significant difference from that given by McAlpine for *M. citri*, except that maximum length of *M. internum* conidia is 75µm in contrast to the 60µm given for *M. citri*. No suggestion was made that conidia might have been produced in chains. The conidium size range and general description of this fungus could fit within a concept of the *Alternaria tenuissima* group if the fungus is indeed an *Alternaria*, which Joly (1964) suggested when he published a new combination *Alternaria interna* (McAlpine) Joly. From the point of view of recognition and identification of this species in modern times, however, I believe that the fungus, though possibly an *Alternaria*, is unknowable in the absence of both illustrations and specimens.

45. 1903 *Alternaria tenuis* Nees f. *chalaroides* Saccardo
Giorn. Vitic. Enol. (Avellino) 11: 132. *Hab. in fructibus vegetis, quos corrumpit, Citri deliciosae in Italia merid.* Holotype: **PAD**, intus fructus Citri deliciosae, Mandarino, Salerno (EGS 11-123).

Saccardo (l.c.) described this forma *chalaroides* on the basis of the endogenous production and release of bacilliform conidia from the ends of olivaceous hyphae, presumed by him to be hyphae of *Alternaria tenuis* Nees, which appeared on diseased citrus peel and fruit tissue held in the humid atmosphere of a Petri dish. He described the endoconidial fungus in considerable detail but not the *Alternaria*, which he refered to simply as *A. tenuis* that sporulated when the tissue and fungal growth were exposed to the air. The type specimen is accompanied by a manuscript drawing of the chalaroid fungus and some short chains of *Alternaria* conidia.

The "forma" represents one component of what appears certainly to be a mixture; as the described component of the mixture, the chalaroid component remains attached to the name (ICBN 9.2; Greuter et al.,1988), which, for nomenclatural purposes, can be handled only among other chalaroid fungi. The *Alternaria* component, undescribed, is divorced from the type specimen and thus is simply a misidentified fungus. The fact that the *Alternaria* component actually is identifiable as *A. citri* Ellis & Pierce is not material to the nomenclatural situation; it can be cited as a specimen containing *A. citri* but it's name, as a form, cannot be synonymized with *A. citri*.

46. 1908 *Macrosporium dictamni* Lindau Fig. 51
in Rabenhorst's Krypt.-Fl., Pilze, 9: 244. *Auf dürren Stengeln von Dictamnus albus, die am Boden lagen, am Enzberg bei Laucha i. Thür. (Oertel); im September.* Holotype: B, Auf . . . Stengeln von Dictamnus albus. Laucha: Enzberg. 5/9. 07. Oertel (EGS 10-084).

Lindau's (l.c.) description and type specimen are of a fungus that is one of the most commonly encountered *Alternaria* species known on herbaceous debris in temperate climates.

Fascicles of more or less erect, brittle (when dry), medium tan conidiophores commonly 40-60 x 4-5µm in size arise from microstromatic knots of dark cells; one apical conidiogenous site and often a second at the end of a geniculate branch of the conidiophore are usual in field specimens.

Conidia are ovoid to broadly ellipsoid, usually tapering apically into a short, narrow (10-20 x 2µm) but not filiform beak; conidia are pale to medium tan, essentially smooth, commonly up to 45-55 x 17-20µm, with 3-4 readily visible primary plus 1-4 series of pale secondary transverse septa and 1-3 longitudinal septa in most of the transverse segments; conidia are slightly constricted at primary transverse septa; rarely (in this specimen) a conidium generates apically a secondary conidiophore with several sporulation sites (evidence of branching chains of conidia). Lindau's conidium measurements are 23-40 x 8-12µm with transverse septation 3-4 or occasionally more. His sketches on the type packet show conidia similar to many I have seen in the type specimen, so it is assumed that his sample was of younger conidia than was mine.

Although this fungus is an excellent example of a commonly encountered species of *Alternaria*, there is no point in proposing a new name combination based on *M. dictamni*. There are numerous earlier names in the literature for this species; the choice of the correct name awaits convincing proof that I (or someone) can positively and consistently correlate this species in its natural appearance with a definable and predictable appearance in culture. This present essay is not the appropriate place to propose and support such a choice.

47. 1910 *Stemphylium citri* Patterson & Charles

in Patterson, Charles and Viehmeyer, U.S. Dept. Agr., Bur. Pl. Ind., Bull. no. 171, p. 14. *Specimens of oranges affected by what is locally known as "end-rot" in Arizona . . . in 1907 and again in 1908.* Holotype: BPI, from orange, Arizona, "Nov. 1907 or Dec. 1908 [sic], Natural growth"; permanent slide no. 1, as type of *Stemphylium citri* Patterson & Charles (EGS 08-075).

No illustrations were included with the very brief type description of *S. citri*. Several permanent slide preparations in BPI represent natural and cultivated material studied by the authors. From these I have chosen a slide marked "Type" prepared from "Natural Growth" and possibly, though not certainly representing the earliest material studied by the authors.

The fungus is *Alternaria citri* Ellis & Pierce, of which *Stemphylium citri* Patterson & Charles is a synonym.

48. 1912 *Macrosporium fagaricola* Spegazzini

Anal. Mus. Nac. Buenos Aires 23: 124. *Ad folia languida Fagarae cujabensis in silvis prope Puerto Leon, Misiones, Aug. 1909.*

Spegazzini (l.c.), in describing a fungus on leaf spots of *Fagara (= Zanthoxylum*; Rutaceae), noted solitary conidia on the tips of clumped conidiophores; conidia were smooth, olivaceous, straight, ellipsoid, pellucid, 30-50 x 15-20µm, rounded at the base and wedge-shaped at the apex, sometimes with an apical extension 10-30 x 5-6µm; with 3 transverse and 1 longitudinal septa. (This description is an interpretation, based on the assumption that Spegazzini,

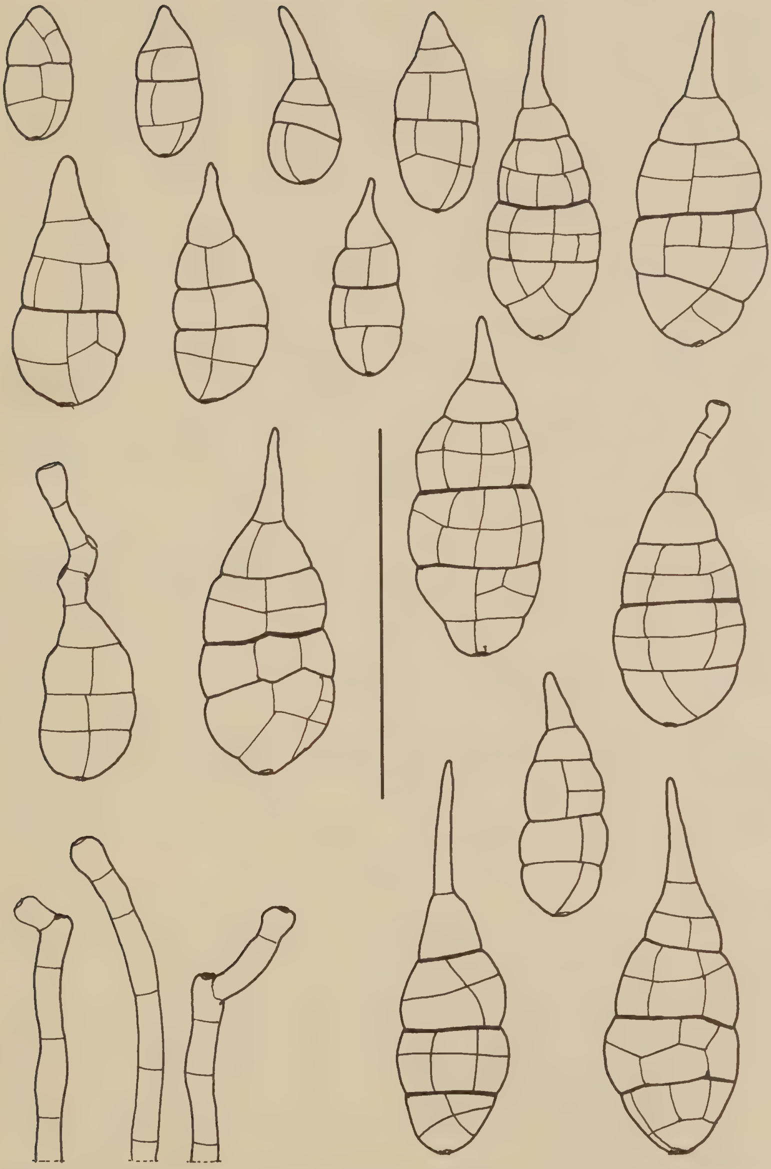

Fig. 51. MAcrosporium dictamni; conidia and conidiophores, ex Type. Magn.: vertical bar = 50μm.

like most other mycologists of that time, believed that conidia of *Macrosporium (Alternaria)* were attached by their narrow end.) However, if this fungus is indeed an *Alternaria*, it would be a striking and most unusual one with its moderately long conidia having only three transverse septa.

Spegazzini's type specimen apparently is lost; it could not be found among his specimens at **LPS**. No illustrations accompany the type description.

Joly (1964) made the transfer *Alternaria fagaricola* (Speg.) Joly. I consider the fungus to be unplaceable, even to genus, on the basis of the available information.

. **1913 *Macrosporium hesperidearum* Pantanelli in Pantanelli and Cristofoletti, Staz. Sperim. Agr. Ital. 46: 641. *Hab. in fructibus vivis Citri Aurantii, quos vexat (Campania.).* Type: original description (l.c.) and illustration (l.c., Tav. XIX, fig. 9); type or other original material of this species has not been found at **PAV**, **PAD**, **ROPV**, or numerous other herbaria.

The original description is accompanied by an illustration that gives some clues to the small size, few septa and cells, and smooth walls of the conidia. All of these characters are included in the description, along with terms that can be interpreted to indicate production of secondary conidiophores and secondary conidia.

I have used these several characters to support the combination *Alternaria hesperidearum* (Pantanelli) Simmons and its use for a distinctive citrus inhabitant represented by several modern specimens. **See section 30 above.

49. 1913 *Stemphylium citri* Patterson, Charles & Veihmeyer in Saccardo, Syll. Fung. 22: 1406.

This author attribution correctly should read *Stemphylium citri* Patterson & Charles, in Patterson, Charles and Veihmeyer. See section 47 above.

50. 1944 *Alternaria citri* Ellis & Pierce, emend. Bliss & Fawcett
Mycologia 36: 488.

The Bliss and Fawcett "emendation" and an associated "neotype" specimen are informative and very helpful in sorting out *Alternaria* species known on citrus materials. However, their emendation is not based on the Ellis and Pierce type specimen, which they could not locate, but on their own isolates. It is fortunate under the circumstances, I believe, that their selected isolate is identifiable with Pierce's specimen. Nevertheless, the species remains typified by the original Ellis and Pierce publication (1902) and by the Pierce specimen that was shared with Ellis (BPI, as *Macrosporium citri* Ell. & Ev.). See section 28 above.

51. **1959** *Alternaria citri* Ellis & Everhart
in Sawada, Natl. Taiwan Univ., Coll. Agr. Spec. Bull. 8, p. 206.

This authority attribution in Sawada (l.c.) must be interpreted simply as an error, since an accompanying literature citation is to "Pierce, Bot. Gaz. 33: 234 (1902)," i.e., directly and specifically to the correct source of an earlier, validly published name. There is no indication that a substitute name was intended.

52. **1964** *Alternaria fagaricola* (Spegazzini) Joly
Encycl. Mycol. 33: 200.

This is a name combination from *Macrosporium fagaricola* Spegazzini (1912); no reference is made to type or other specimens. See section 48 above.

53. **1964** *Alternaria interna* (McAlpine) Joly
Encycl. Mycol. 33:205.

This is a name combination from *Macrosporium internum* McAlpine (1902); no reference is made to type or other specimens. See section 44 above.

ACKNOWLEDGEMENTS

Dr. Mary E. Palm instigated this survey of species of *Alternaria* and somewhat similar fungi on Rutaceae when she invited me to examine her excellent isolates from Mexican limes; much of the information contained in the discussion of *Alternaria limicola* is from her laboratory. Dr. Palm also did me the signal favor of reviewing the entire manuscript critically and expeditiously, for which I am grateful. Individuals and herbaria that generously have allowed me access to their collections over the years are noted in the text. I am especially grateful to the CAB International Mycological Institute and its staff, who, over several decades, have shared with me many hundreds of collections and isolates and much background information that are crucial to studies of *Alternaria* and similar genera.

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MYCOTAXON

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FUSARIUM MORPHOLOGY I: IDENTIFICATION AND CHARACTERISATION OF A THIRD CONIDIAL TYPE, THE MESOCONIDIUM.

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SUMMARY:

A third type of Fusarium conidium, termed the mesoconidium, is defined and compared with macroconidia and microconidia. Mesoconidia are produced singly and holoblastically in the aerial mycelium from conidiogenous cells which proliferate sympodially. Mesoconidia do not accumulate in slimy false heads or chains, and are readily detected by direct observation of cultures with the low power objective of the compound microscope. They are mostly septate, fusoid or falcate in shape, and have a simple truncate basal cell. Mesoconidia and mesoconidiophores are described for six *Fusarium* species; *F. avenaceum*, *F. chenopodinum*, *F. chlamydosporum*, *F. pallidoroseum* (*F. semitectum*), *F. sporotrichioides* and *F. subglutinans*.

INTRODUCTION

The genus *Fusarium* Link: Fr is typified by *F. roseum* Link: Fr., the type specimen of which has septate, falcate conidia with a pedicellate (foot-shaped) basal cell (Wollenweber, 1916-35, Wollenweber & Reinking, 1935). It is well known that many species produce more than one type of conidium; macroconidia similar to those by which the genus is typified, and microconidia which are smaller and generally non-septate. Microconidia in some species (e.g. *F. solani* (Mart.) Sacc., *F. subglutinans* (Wollenw. & Reinking) Nelson, Tousson & Marasas) also differ from macroconidia in the morphology of their conidiogenous cells. A third kind of conidium which is morphologically and developmentally distinct from both macroconidia and microconidia, also occurs in some species but has been ignored or only scarcely recognised by most *Fusarium* taxonomists.

In 1971 Booth used conidiogenesis as a major criterion in *Fusarium* classification. He drew attention to the occurrence of "polyblastic" conidiogenesis in some species and used this criterion to unite *F. sporotrichioides* Sherbakoff and

F. fusarioides (Frag. & Cif.) Booth (with polyblastic microconidia) with *F. avenaceum* (Fr.) Sacc., *F. semitectum* Berk. & Rav. and *F. camptoceras* Wollenw. & Reinking (with polyblastic macroconidia) in an expanded section *Arthrosporiella* Sherb. This move was not accepted by a majority of *Fusarium* taxonomists who preferred to follow Wollenweber & Reinking (1935) by placing *F. avenaceum* in *Fusarium* sect. *Roseum*, *F. sporotrichioides* and *F. chlamydosporum* Wollenw. & Reinking (*F. fusarioides* sensu Booth) in *F.* sect. *Sporotrichiella* Wollenw. and *F. semitectum* and *F. camptoceras* in *F.* sect. *Arthrosporiella*. Gams (1982) felt that Booth's use of conidiogenesis as a sectional criterion in this case was inconsistent with Booth's use of conidiogenesis as a varietal criterion in F. sect. *Liseola*. Booth however, obviously regarded the difference between phialides and polyphialides (in sect. *Liseola*) as much less significant than the difference between phialides and conidiogenous cells producing only a single conidium from each conidiogenous locus. Booth's work was foreshadowed by that of Seemuller (1968) who, in his study on *F.* sect. *Sporotrichiella*, drew attention to the occurrence in *F. chlamydosporum* and *F. sporotrichioides* of conidiogenous cells which he compared with section II of Hughes (1953).

In the species dealt with by Booth and Seemuller as having "polyblastic" microconidia (i.e. holoblastic conidia with sympodially proliferating conidiogenous cells) these microconidia are often 1-, 2-, or 3-septate, which is unusual in species which produce microconidia on phialides (e.g. *F. oxysporum*, *F. solani*). In those species with "polyblastic primary macroconidia" sensu Booth, these conidia do not bear the characteristic foot-shaped basal cell of sporodochial macro-conidia ("secondary macroconidia" sensu Booth). In addition, holoblastic sympodial micro- and macroconidia in these species are produced singly and are thus dry in appearance rather than being produced in a basipetal series and accumulating in slimy masses or false chains. Other literature dealing with *Fusarium* taxonomy reveals that the phenomenon of atypical, dry conidia in the aerial mycelium has been observed many times, and that the application of the terms "microconidium" and "macroconidium" to these conidia has been arbitrary and inconsistent.

Throughout the literature on *F. sporotrichioides* attention is drawn to the occurrence of two types of microconidia; 0-1-septate, pyriform or ovoid microconidia and 0-3-septate, fusoid or falcate microconidia. The latter, fusoid-falcate apedicellate conidia are termed microconidia although some may be almost as large as macroconidia (see dimensions given by Gerlach and Nirenberg, 1982). In fact the larger ones have probably frequently been mistaken for macroconidia. Samson et al. (1981) illustrate fusoid-falcate, 2-5-septate apedicellate conidia as macroconidia, and state that macroconidia do not have pedicellate basal cells. Other authors (e.g. Seemuller, 1968, Gerlach & Nirenberg, 1982, Nelson et al., 1983) illustrate pedicellate, strongly falcate macroconidia in addition to fusoid-falcate 1-3-septate microconidia and 0-1-septate pyriform microconidia. Thus, although there is some confusion over terminology, most authors appear to recognise three distinct conidial types in *F. sporotrichioides*, the intermediate type between pyriform micro-conidia and pedicellate macroconidia being characterised by septate, fusoid-falcate, apedicellate conidia produced from conidiogenous cells that proliferate sympodially.

In *F. semitectum* (*F. pallidoroseum* (Cooke) Sacc. fide Booth & Sutton,

1984) similarly shaped apedicellate conidia are invariably termed macroconidia, partly because they are larger and more uniform than in *F. sporotrichioides*, but principally because pedicellate macroconidia, especially from sporodochia, have seldom been described in this species (but see Nelson, Tousson and Marasas, 1983 and Burgess & Liddell, 1983). In *F. avenaceum* fusoid, apedicellate, holoblastic conidia are referred to by Booth (1971) as "primary macroconidia" while Nirenberg (1981) calls the same conidia "primary microconidia" despite the fact that they are over 30 μm long. Samson et al. (1981) refer to these conidia as macroconidia in their key to species, but as "(micro)conidia from polyblastic conidiogenous cells" in their description of *F. avenaceum*. Similarly, Nelson, Tousson and Marasas (1983) include *F. avenaceum* in their key amongst those species with "macroconidia spindle-shaped and produced on monophialides or polyphialides in the aerial mycelium", but in their description and illustrations they refer to these conidia as microconidia. In discussing distinctions between macro- and microconidia they state that "difficulties arise in those species having 3-4-septate spindle-shaped conidia".

It is clear from the above discussion that there is confusion regarding the delimitation of microconidia and macroconidia and that this confusion might be resolved by recognising that a third kind of *Fusarium* conidium exists which is distinct from the typical microconidia of sections *Elegans*, *Martiella*, *Liseola*, and *Spicarioides*, and from the typical pedicellate, falcate macroconidia by which the genus is typified. This third type of conidium is produced holoblastically from sympodially proliferating conidiogenous cells as single, dry conidia which may be 0-5-septate, fusiform, lanceolate, or weakly falcate and which lack a pedicellate basal cell. Since this type of conidium is in many ways intermediate between the microconidium and the macroconidium I propose the term mesoconidium. Macroconidia, mesoconidia and microconidia are defined as follows (see also Table 1).

Macroconidia. Falcate, (1-)3-5(-9)-septate, with a lateral, cellular appendage on the basal cell which gives it a characteristic "foot-shaped" appearance ("pedicellate basal cell" or "footcell") the "heel" of which represents the point of attachment to the conidiogenous cell. The apical cell is variously tapered and curved, sometimes with a distinct papilla. Conidia are produced in a basipetal succession from phialides and accumulate in slimy masses. Conidiomata may be classified into three categories:

i) Simple lateral phialides or sparsely branched small (micronematous) conidiophores arising from undifferentiated hyphae in the aerial mycelium or on the substrate surface and producing small masses of variable, often atypical and apedicellate macroconidia, many of which may resemble microconidia.
ii) Well-developed complex penicillate (macronematous) conidiophores in the aerial mycelium or on the substrate surface, producing moderately large (macroscopically visible) masses of more or less uniform macroconidia.
iii) Complex, stromatic sporodochia, seated on the substrate surface and producing very large, slimy masses of uniform, well developed macroconidia.

Mesoconidia. Straight or curved, fusoid, lanceolate, clavate or falcate, 0-5(-7)-septate, with a simple narrowly truncate basal cell, lacking a lateral appendage ("apedicellate"). Conidiogenous cells produce a single dry conidium from each conidiogenous locus and proliferate sympodially (if at all). Conidiophores are micronematous or semi-macronematous, mostly simple or sparsely branched. Mesoconidia do not accumulate in slimy heads, but remain dry, often giving the aerial mycelium a powdery appearance. Occasionally macroconidia may be produced on the same conidiophore as mesoconidia. Mesoconidia are generally persistent on the conidiophore (which may collapse after conidium production) but are easily dislodged by vibration (e.g. during removal of conidiophores for examination).

Microconidia. Ellipsoid, ovoid, subglobose, pyriform, clavate or allantoid, 0-(1)-septate with a rounded or truncate base. Conidia are produced in a basipetal series on phialides or polyphialides and accumulate in small, slimy false heads or false chains. Conidiophores are micronematous, mostly simple lateral phialides or sparsely branched conidiophores (especially in *F.* sect. *Liseola*) in the aerial mycelium or on the substrate surface. Microconidia are never produced in large masses on stromatic sporodochia.

Table 1. Comparison of macroconidia, mesoconidia and microconidia

	Macroconidia	Mesoconidia	Microconidia
conidiophores			
morphology	micronematous macronematous sporodochial	micronematous semi-macronem.	micronematous
location	aerial/surface	aerial	aerial/surface
aggregations	masses/heads	single	heads/chains
consistency	slimy	dry	slimy/dry
conidiogenous cells	phialidic	holoblastic	phialidic
proliferation	none	sympodial	none or sympodial
conidia			
shape	falcate	fusiform lanceolate falcate	ellipsoid allantoid variable
septation	1-5(-10)	0-5(-7)	0 (-1)
basal cell	pedicellate	truncate	rounded truncate

In using these definitions to identify conidia it is important to pay as much attention to the way in which conidia are produced as to their morphology. On a morphological basis alone, non-septate mesoconidia of *F. chlamydosporum* may be mistaken for microconidia of the chain-forming Liseola species, while mesoconidia of *F. avenaceum*, *F. sporotrichioides* and *F. pallidoroseum* may be mistaken for macroconidia. In addition macroconidia produced from phialides in the aerial mycelium by some species may resemble mesoconidia but are distinguished by their occurrence in small slimy, false heads. Conidiophore morphology is also not absolutely reliable as there is always a proportion of mesoconidiogenous cells which do not proliferate sympodially and resemble typical phialides except for their lack of a conspicuous collarette. Because of the emphasis on conidial production and aggregation rather than morphology, mesoconidia are best detected by direct examination of agar cultures with the low power (10x) objective of the compound microscope, when the habit of conidiophores and conidia can be clearly seen (Fig. 1). With experience the habit of conidiophores when seen in this way will enable tentative identification of the species (see species descriptions below and Fig. 2).

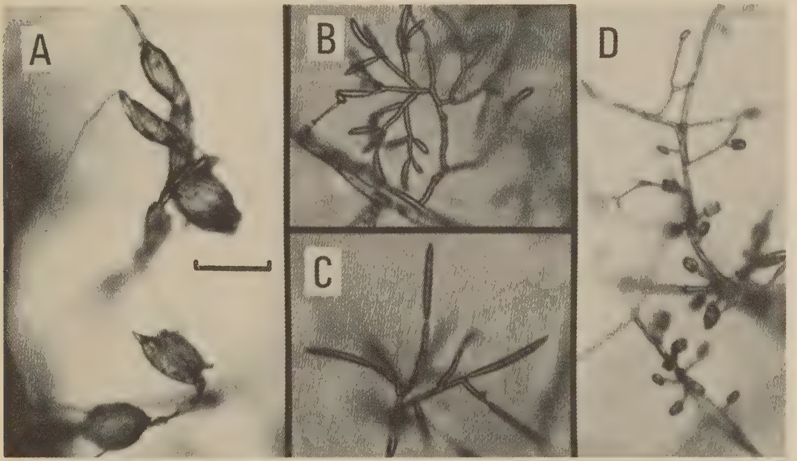


Fig. 1. Habit photographs of *Fusarium* macroconidia, mesoconidia and microconidia in aerial mycelium on carnation leaf agar; **A.** macroconidia of *F. oxysporum*, **B.** mesoconidia of *F. sporotrichioides*, **C.** mesoconidia of *F. pallidoroseum*, **D.** microconidia of *F. oxysporum*. Scale bar: 50 μm.

It is also possible to detect mesoconidia using a good dissecting microscope, although confirmation with the compound microscope is usually necessary. Mycologists who do not first examine cultures directly with the low power objective of the compound microscope, and who do not use the dissecting microscope in slide preparation, will fail to appreciate the concept of mesoconidia and will not be able to identify reliably the conidia seen on their slides.

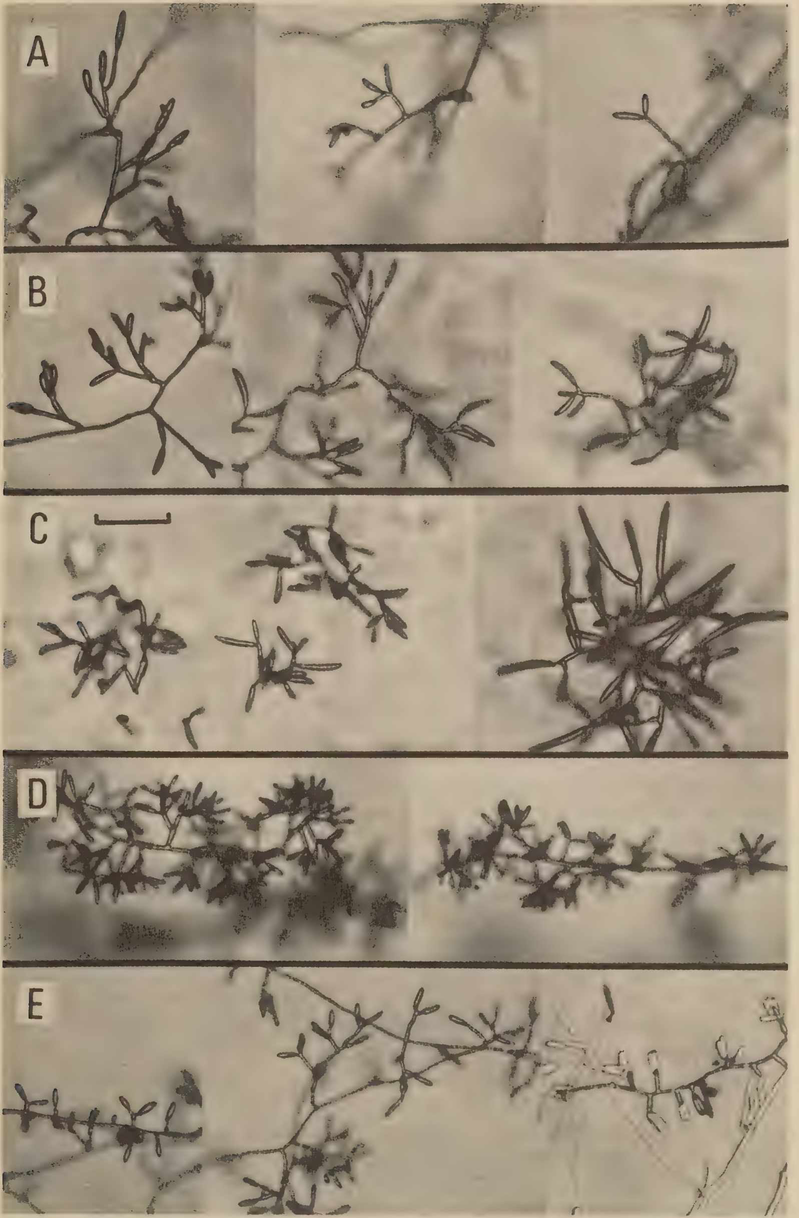
MATERIALS AND METHODS.

Mesoconidia and mesoconidiophores were studied in a total of 18 isolates of six species known to produce mesoconidia. Most isolates were obtained from the Fifth International Fusarium Workshop, Sydney in August 1983, and their identifications can thus be regarded as having been sanctioned by a number of experienced *Fusarium* taxonomists. I am indebted to Dr. Lester Burgess for making these cultures available. All other isolates were identified by me and are from the culture collection of the Plant Research Institute, Burnley (Herb. VPRI). Although all isolates studied are Australian, comparison with non-Australian isolates at the Sydney workshop and overseas indicates that they are all more or less typical of the species, (but see comments below on *F. sporotrichioides*).

All isolates were studied on three media: carnation leaf agar (CLA) (Fisher et al., 1982), special nutrient agar (SNA) (Nirenberg, 1976) and potato dextrose agar (PDA) (Johnson and Booth, 1983). Single conidial isolates were used exclusively. Isolates were first grown on CLA until sporodochia were produced. Single conidial isolations were then made from sporodochial macroconidia. In those isolates of *F. chlamydosporum* and *F. pallidoroseum* which did not produce sporodochia, single conidial isolations were made from mesoconidia. Germinating single conidia were transferred to the three media and incubated for two days at 25°C in a glass-fronted incubator and then under continuous near-ultraviolet light (NUV) (as in Booth, 1971) for 3 days at room temperature. Growth rates were measured on PDA. Cultures were examined for production of mesoconidia and sporodochial macroconidia. Direct low power (10x objective) compound microscope observations were made of the relative abundance of mesoconidia for each isolate and each agar medium, and for the presence of sympodially proliferating conidiogenous cells. Habit photographs and camera lucida habit sketches from SNA were made under low power (10x objective).

Slides were prepared by mounting conidia in a drop of water on a microscope slide and then evaporating the water over a small flame. Slides were then stored under cover until they could be properly mounted and examined. Preparations were examined after adding a drop of alkaline congo red in 50 percent glycerol to the dried smear, adding a coverslip and sealing with several layers of nail varnish. This technique of preparing dried smears for later examination has the advantage of allowing a large number of slides to be made at the same time and then mounted and examined as time permits, thus ensuring that all slides are made at the same developmental stage of the fungi, and that all conidia are examined after approximately the same period of time in the mounting medium. It also has the advantage of fixing all conidia to the glass surface, thus ensuring that they are immobilised and in a single focal plane for drawing or photography. No evidence of distortion of conidial shape or size could be detected.

Fig. 2. Habit photographs of mesoconidia of **A.** *F. avenaceum*, **B.** *F. sporotrichioides*, **C.** *F. pallidoroseum*, **D.** *F. chlamydosporum*, **E.** *F. chenopodinum*. Scale bar: 50 μm.


A
B
C
D
E

All drawings of conidia and conidiophores were made using the 100x oil immersion objective on either a Leitz Dialux or Olympus BHS microscope with a Leitz or Olympus drawing tube (respectively) containing a Leitz 25x eyepiece. With both microscopes the drawing tube and drawing position were adjusted to give exactly the same scale to all drawings. Habit sketches were made using the 10x microscope objective and drawing tube as above. Habit photographs were taken on the Olympus microscope with 10x objective. It should be noted that the drawings of mesoconidia have been chosen to illustrate the full range of sizes and septation classes. It should not be assumed that the drawings represent accurately the relative abundance of size and septation classes. Especially in *F. chlamydosporum* where small, non-septate conidia are both extremely abundant and uniform, disproportionate emphasis has been given to larger, septate mesoconidia.

RESULTS

The descriptions which follow are based solely on the specimens examined. They are biased towards mesoconidia and as such only address the macroscopic appearance of cultures, habit of conidiophores and morphology of mesoconidia and mesoconidiophores. Macroconidia and microconidia are included in the illustrations for those isolates in which they occur, for comparison with mesoconidia. Chlamydospores have not been included in descriptions or illustrations.

F. avenaceum **(Fr.) Sacc.** - six isolates studied (see figs. 3-8).
PDA. Average growth rate (radius) after 6 days at 20-25°C, 37 mm (range 34-39). Cultures in reverse pale to deep carmine, or carmine with brownish radial sectors, or entirely yellow-brown or deep sepia-brown. Aerial mycelium pink, abundant, dense. Sporulation often rather poor, but some isolates developing abundant macroconidial masses centrally on the agar surface, or in the aerial mycelium. Mesoconidia sparse and difficult to detect because of the density of aerial mycelium, most frequently found towards the margins of the colony, or not at all in some isolates.
CLA. Pigment mostly absent, although in some isolates a carmine pigment may accumulate around the carnation leaf pieces. Large orange sporodochia are produced on the carnation leaf pieces. Aerial mycelium is thin, bearing sparse to moderately abundant mesoconidia on long, loosely branched conidiophores.
SNA. Pigment lacking, growth sparser than on other media, macroconidia produced in small slimy masses on the agar surface. Mesoconidia usually abundant, scattered throughout the aerial mycelium, on long, loosely branched conidiophores.
Mesoconidiophore and Mesoconidium Morphology. Mesoconidiophores arise from the aerial mycelium or vertically from the agar surface and vary from unbranched and monoconidial, to complex conidiophores with an open branching pattern bearing single mesoconidia at the end of each branch or sympodial proliferation (Fig. 2). Sympodial proliferation is not as abundant in *F. avenaceum* as in the other species studied. Conidiogenous cells proliferate sympodially from about 2 μm below the point of attachment of the previous conidium. The

proliferation may then grow on as much as 100 μm, often becoming septate before production of the next conidium, and occasionally continuing as a simple hypha without further conidium production. Occasionally 2, or even 3 conidia are produced from adjacent loci on a single conidiogenous cell. After conidial secession a broad (1-1.5 μm diam.), flat or domed, unthickened scar remains with an inconspicuous marginal frill. There is no visible periclinal thickening. Mesoconidia are mostly straight, occasionally slightly curved, fusiform to lanceolate, 9-52 x 3-5 μm, 0-5-septate, apical cell tapered to a rounded point,

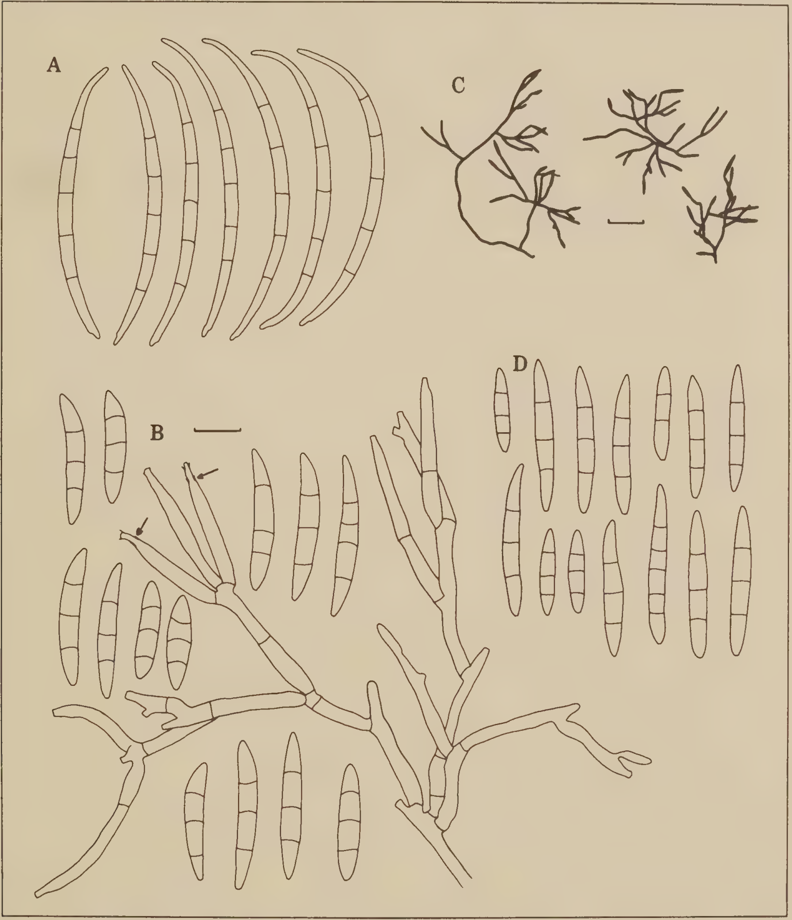


Fig. 3. *F. avenaceum* (VPRI 11908) **A**. Macroconidia from sporodochia on CLA; **B**. Mesoconidia and mesoconidiophores from CLA, (note two percurrently proliferating macroconidiogenous cells, arrows); **C**. Habit sketch, SNA; **D**. Mesoconidia from SNA. Scale bars; B:10 μm, C:50 μm.

basal cell truncate (truncation 1.0-1.5 μm wide). 3-septate conidia are most common and characteristic, 15-40 μm long (av. 26 μm), x 3-5 μm wide (mostly 3.5-4.0) varying a little between isolates, but not between media, although on PDA fewer 3-septate conidia are produced. 0-1-septate mesoconidia are common and 9-22 μm long, 2-septate conidia are similar in size to 3-septate conidia, the rather rare 4-5-septate mesoconidia are 35-52 μm long.

Specimens examined: VPRI 11907, isolated from roots of *Trifolium subterraneum*, Clunes, Victoria, 8 Feb. 1983, F. Greenhalgh; VPRI 11908, isolated

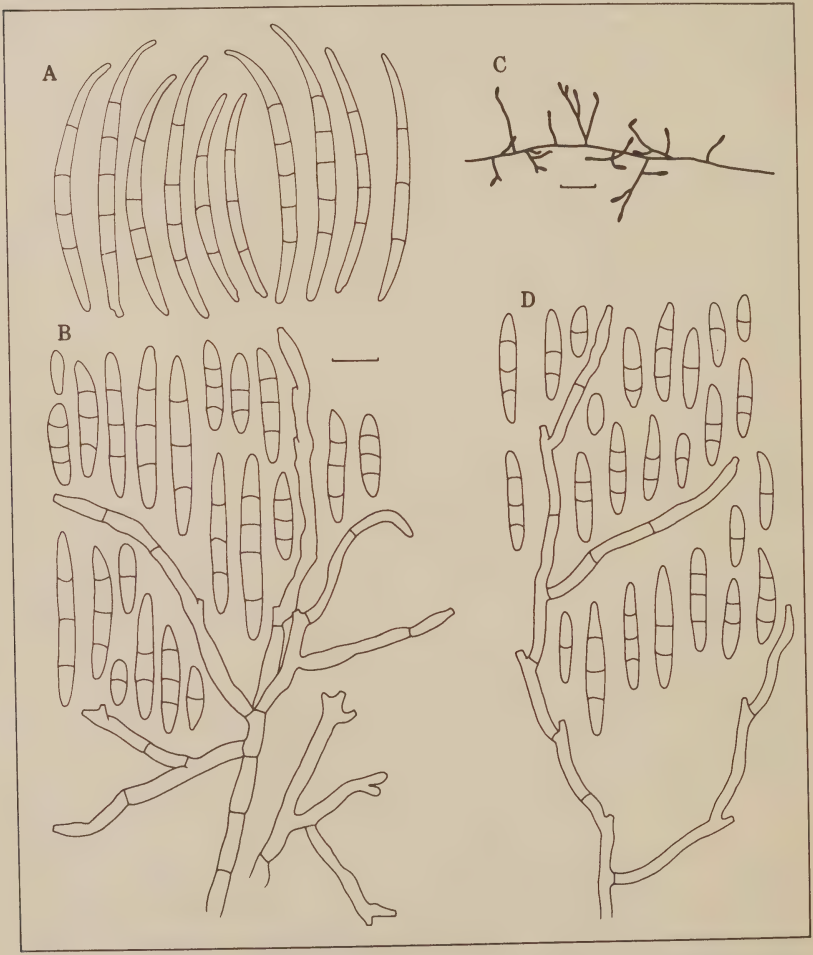


Fig. 4. *F. avenaceum* (VPRI 12045) **A**. Macroconidia from sporodochia on CLA; **B**. Mesoconidia and mesoconidiophores from CLA; **C**. Habit sketch, SNA; **D**. Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, C:50 μm.

from roots of *Trifolium subterraneum*, Boxwood, Victoria, 5 Oct. 1982, F. Greenhalgh; VPRI 12041, isolated from wheat roots, Forbes, N.S.W., L. W. Burgess, FRL 6614; VPRI 12042, isolated from Pine nursery soil, Bombala, N.S.W., L. W. Burgess, FRL 4661; VPRI 12045, isolated from pasture soil, Hay, N.S.W., L. W. Burgess, FRL 3047; VPRI 12175, isolated from roots of *Trifolium subterraneum*, Joel South, Victoria, 18 Nov. 1983, F. Greenhalgh.

Of the six species studied, *F. avenaceum* is the least reliable producer of

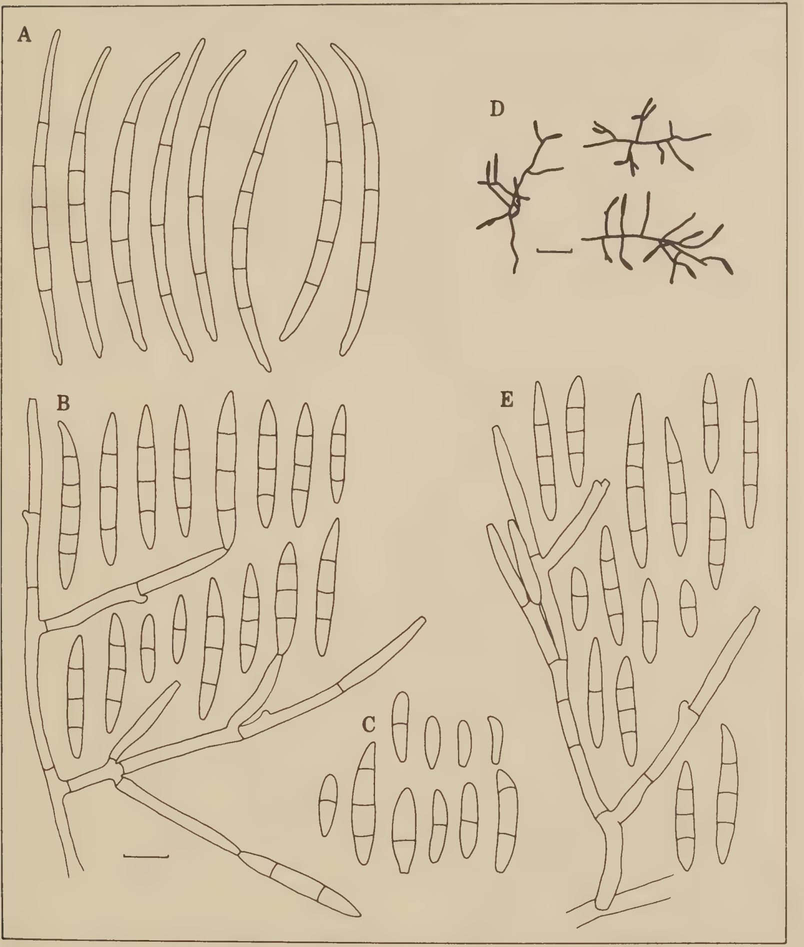


Fig. 5. *F. avenaceum* (VPRI 11907) **A.** Macroconidia from sporodochia on CLA; **B.** Mesoconidia and mesoconidiophores from CLA; **C.** Mesoconidia from PDA; **D.** Habit sketch SNA; **E.** Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, D:50 μm.

mesoconidia. It rarely produces mesoconidia on rich media such as PDA/PSA and OMA and plant pathologists working with these media have difficulty applying Booth's (1971) description of "polyblastic primary macroconidia" to cultures of *F. avenaceum*. Booth himself observed that these conidia were produced on PSA only in fresh cultures, being very rare in subsequent subcultures. This observation is supported by the present work where mesoconidia were seldom seen on PDA (all of the isolates used had been in culture for some time). Nevertheless every isolate of *F. avenaceum* studied by me at CMI, Kew and CBS, Baarn during 1982, and at the 5th International Fusarium

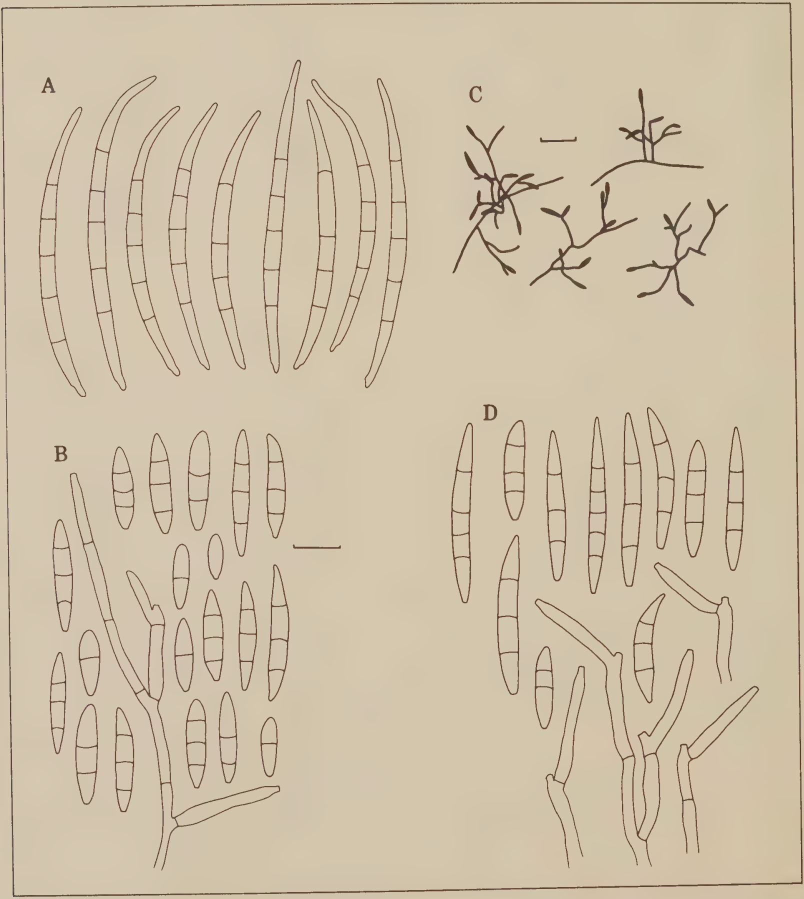


Fig. 6. *F. avenaceum* (VPRI 12175) **A**. Macroconidia from sporodochia on CLA; **B**. Mesoconidia and mesoconidiophores from CLA; **C**. Habit sketch from SNA; **D**. Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, C:50 μm.

Workshop, Sydney, 1983 has produced mesoconidia on CLA, SNA or water agar. An isolate of Wollenweber's (IMI 91978) produced abundant mesoconidia on SNA in 1982 despite having been in culture since 1931.

Nirenberg (1981) observed and illustrated typical mesoconidia of *F. avenaceum* (as microconidia) and described their conidiogenesis as polyblastic, as did Samson et al.(1981). Gerlach & Nirenberg (1982) described, but did not illustrate, mesoconidia (as primary macroconidia). Domsch, Gams and Anderson (1980) (presumably working with OMA) regarded "microconidia" of *F. avenaceum*

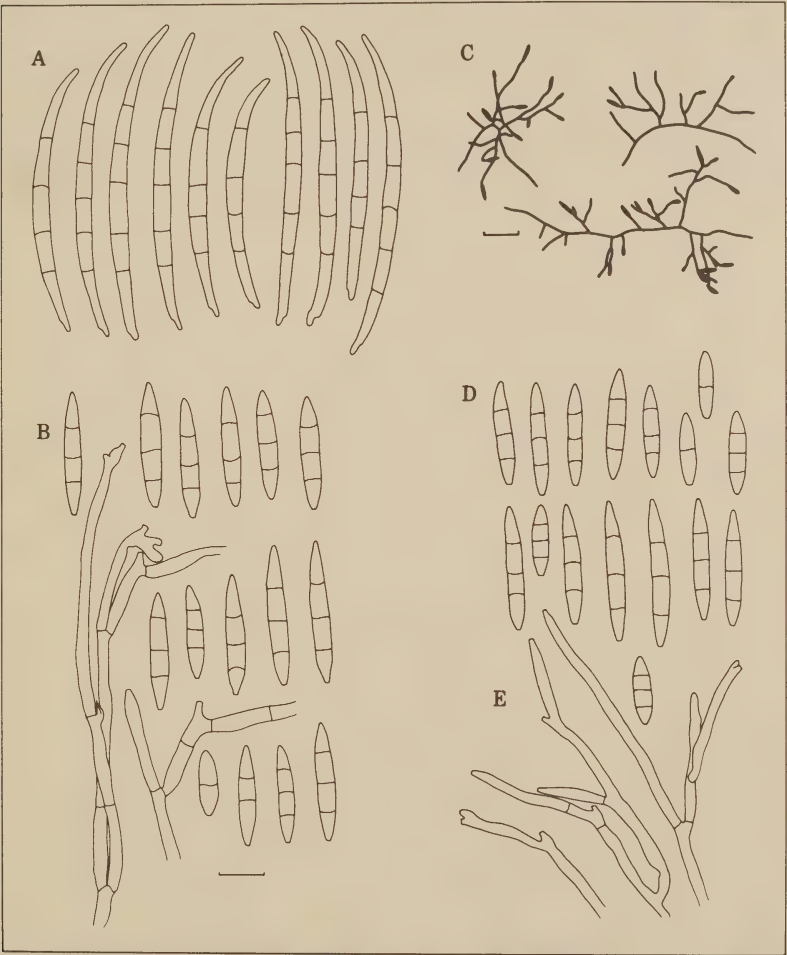


Fig. 7. *F. avenaceum* (VPRI 12041) **A**. Macroconidia from sporodochia on CLA; **B**. Mesoconidia and mesoconidiophores from CLA; **C**. Habit sketch, SNA; **D**.,E. Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, C:50 μm.

as rare and described conidiogenesis as polyphialidic; their illustration shows typical mesoconidia. Nelson, Tousson and Marasas (1983) illustrated mesoconidia (as microconidia) but insisted that conidiogenous cells were merely "branched monophialides" rather than polyphialides.

F. avenaceum shows great variability in the morphology of its mesoconidiophores. While some isolates produce complex, highly branched conidiophores (e.g. Fig. 3) others produce simple or sparsely branched conidiophores laterally from aerial hyphae (Fig. 6). In some isolates, especially those showing some sign of degeneration, there is a tendency for mesoconidiophores to become increasingly hyphal in nature, so that mesoconidiogenous loci are found at irregular intervals along more or less indeterminate hyphae (see Fig. 8). In other isolates it is difficult to find sympodially proliferating conidiogenous cells. It is not uncommon to see macroconidia produced from the same conidiophores as mesoconidia, and on several occasions I have observed a single conidiogenous cell with a mesoconidium and a macroconidium attached, the mesoconidium apparently

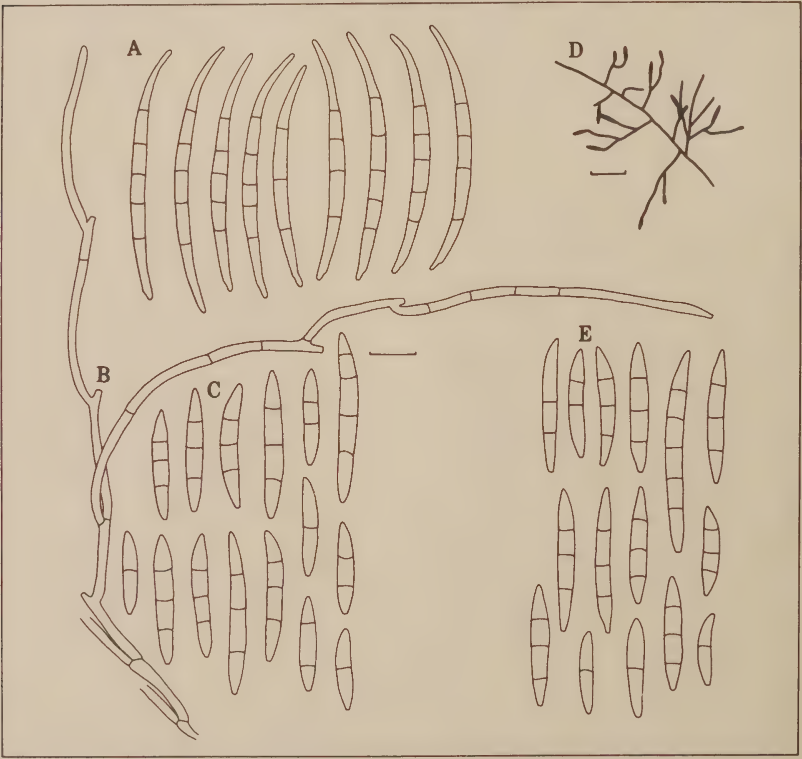


Fig. 8. *F. avenaceum* (VPRI 12042) **A**. Macroconidia from sporodochia on CLA; **B**. Mesoconidiophores from CLA; **C**. Mesoconidia from CLA; **D**. Habit sketch, SNA; **E**. Mesoconidia from SNA. Scale bars; C:10 μm, D:50 μm.

ERRATA, VOLUME THIRTY-SEVEN

Page	135	line	46	for	*anguiodes*	read	*anguioides*
	136		45	*for*	neligherrense	*read*	neilgherrense

having been produced first. Such a case suggests that mesoconidiogenous cells can occasionally proliferate percurrently and begin to produce macroconidia. Note in Fig. 3B two percurrently proliferating, phialidic macroconidiogenous cells.

Mesoconidia also show considerable morphological variability, but disregarding the obvious aberrations, and those with less than three septa, seem to fall into two groups; long, slender lanceolate or fusiform mesoconidia, which are 3-5-septate, over 25 μm long and less than 4 μm wide; and short, stout, broadly fusiform, 3-septate conidia, 20 μm or less in length and over 4 μm wide. The latter conidia are less common in culture (there are good examples in Figs. 6B & 7D), but may be predominant on naturally infected host tissue. Of course, there are invariably some intermediates, but it is important to recognise that both types are typical of *F. avenaceum*.

Many authors (Gerlach & Nirenberg, 1982, Wollenweber & Reinking, 1935 Messaien & Cassini, 1968, Gordon, 1952, Cormack, 1951) have used the name *F. arthrosporioides* Sherbakoff for those isolates which are essentially identical to *F. avenaceum* in cultural and macroconidial characters but which produce mesoconidia. The name *F. avenaceum* was used by these authors for isolates without mesoconidia. All of the isolates studied in this paper as *F. avenaceum* should, according to these authors, be identified as *F. arthrosporioides*.

Nirenberg (1981) suggests that the principle difference between the species is the presence of polyphialides in *F. arthrosporioides* but not in *F. avenaceum*, although her illustration of *F. avenaceum* clearly shows sympodially proliferating conidiogenous cells. I can see no reason for maintaining the species as distinct on the basis of such fragile criteria, especially since all isolates of *F. avenaceum* examined at CMI, CBS and the Sydney workshop have mesoconidia. I have examined a Sherbakoff specimen of *F. arthrosporioides* grown on a piece of raspberry cane (CUP 7467) and it has good mesoconidia similar to the *F. avenaceum* isolates described here, but does not have any macroconidia. Until the type specimen of *F. avenaceum* is located it will not be possible to determine whether the species are distinct.

For the time being it is preferable to regard *F. avenaceum* and *F. arthrosporioides* as synonyms. Any isolates which lack mesoconidia can usually be referred to *F. acuminatum* sensu lato after careful examination of sporodochial macroconidia and chlamydospore production on CLA. The problems of differentiating *F. acuminatum* and *F. avenaceum* will be dealt with in a later paper. *Fusarium diversisporum* Sherbakoff is also similar to *F. avenaceum*, although several authors have regarded it as being closer to *F. semitectum* (Booth 1971, Nelson et al. 1983, Gerlach & Nirenberg, 1982). Examination of a Sherbakoff specimen of *F. diversisporum* grown on a piece of raspberry cane (CUP 7430) reveals that the species is identical in every respect with the isolates of *F. avenaceum* described in this paper, having typical sporodochial macroconidia, mesoconidia and sympodially proliferating mesoconidiophores. Gerlach and Nirenberg (1982) describe an isolate (strain 11129) which they claim is typical of *F. diversisporum*; their description and illustrations agree well with my illustrations of *F. avenaceum*. I have not seen any of Sherbakoff's specimens of *F. anguiodes* Sherbakoff but suspect that this species is also synonymous with *F. avenaceum*.

It is possible that the isolates described by various authors as *F. arthrosporioides* and *F. diversisporum* have simply been isolates of *F. avenaceum* which were particularly prolific producers of mesoconidia on the rich (high sugar) media usually used, and which would not be distinguishable from other *F. avenaceum* isolates on weak media such as CLA and SNA.

***F. pallidoroseum* (Cke.) Sacc.**, (*F. semitectum* auct.) - Four isolates studied. (See Figs. 9-12)
PDA. Average growth rate (radius) after 6 days at 20-25°C, 47 mm (range 46-48). Cultures in reverse buff to pale pink or clay to dark brown. Aerial mycelium pale pink, dense, often depressed and yellowish centrally. Sporulation usually abundant in the aerial mycelium, sometimes with small orange masses of macroconidia produced centrally on the agar surface and abundant mesoconidia scattered throughout the aerial mycelium.
CLA. Pigmentation lacking although in some isolates the carnation leaf pieces may become brown. Macroconidia produced as sporodochia on carnation leaf pieces in some isolates (11965, 12075, 12078) and rarely (11965) as spore masses on the agar surface, but one of the isolates studied (12003) produced only a few macroconidia in the aerial mycelium as small spore masses amongst mesoconidia. Aerial mycelium variable in abundance, usually dense over the carnation leaf pieces. Mesoconidia abundant in the aerial mycelium or on short conidiophores close to the agar surface. Mesoconidial production and mesoconidiophore branching pattern much denser than in *F. avenaceum*.
SNA. Pigment lacking, aerial mycelium sparse, macroconidia lacking. Mesoconidia abundant, produced on short conidiophores mostly arising directly from the agar surface or from the sparse aerial mycelium.
Mesoconidiophore and mesoconidium morphology. Mesoconidiophores arising from the aerial mycelium or vertically from the agar surface, loosely and irregularly branched but more compact than those of *F. avenaceum*. Sympodial proliferations readily apparent under direct low power observation (fig. 2) and bearing a single conidium at each conidiogenous locus. Conidiogenous cells usually proliferating sympodially after production of the first mesoconidium from about 1-2 μm below the conidial scar, the proliferation often growing on to become septate and branched. Most conidiogenous cells have only two conidiogenous loci, although 3 or 4 may sometimes been seen. After conidial secession a broad, flat or domed, unthickened scar remains, with an inconspicuous marginal frill. Mesoconidia are fusiform or falcate, mostly 3-5(-7)-septate, 7-56 x 3-4.5 μm, the apical cell curved and tapered to a blunt point, generally a little longer than the basal cell, which is more or less straight with an inconspicuous basal truncation 1-1.5 μm wide. 3- and 5-septate conidia are about equally common, except on PDA where there is a much higher frequency of 3-septate conidia; 3-septate conidia are 15-36 μm long and 5-septate conidia are 30-47 μm long. Frequency of septation classes varies between isolates, some isolates having very few 5-septate conidia and a majority of 3-septate conidia.
Specimens examined:
VPRI 11965, Isolated from *Populus* sp., stem canker, Wangaratta, Vic., A. Allen, 26 April, 1983; VPRI 12003, Isolated from *Zinnia* sp. seed, imported from

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Holland, M. Lane & M. Mebalds, 6 July, 1983; VPRI 12075, isolated from pasture soil, Coffs Harbour, N.S.W., L.W. Burgess, FRL 4958; VPRI 12078, Isolated from *Glycine max*, N.S.W., L. W. Burgess, FRL 6784.

According to Booth & Sutton (1984), *F. pallidoroseum* is the correct name

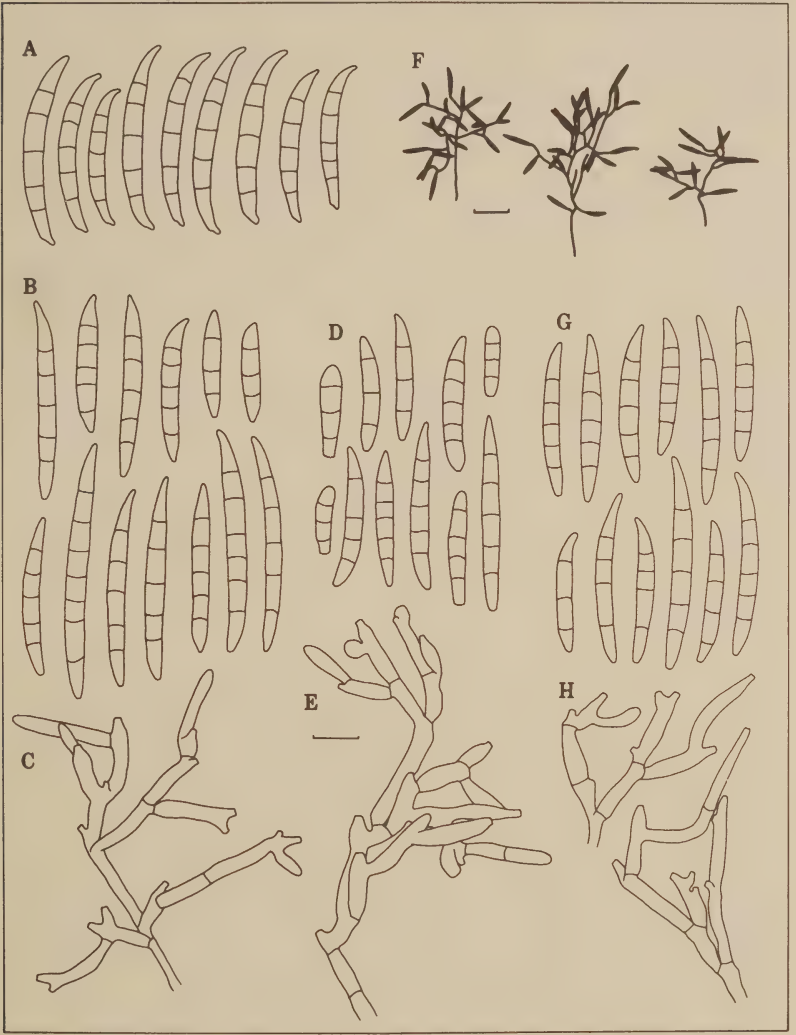

Fig. 9. *F. pallidoroseum* (*F. semitectum*) (VPRI 12078) **A.** Macroconidia from sporodochia on CLA; **B.,C.** Mesoconidia and mesoconidophores from CLA; **D.,E.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch, SNA; **G.,H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; E:10 μm, F:50 μm.

for *F. semitectum* auct. This species is a very reliable and prolific producer of mesoconidia, to the extent that most descriptions of *F. semitectum* in the literature are based exclusively on mesoconidia (as macroconidia) and many descriptions (Booth 1971, Domsch et al. 1980, Samson et al. 1981, Gerlach & Nirenberg, 1982) claim that sporodochia are never produced. Matsushima (1971) described the genus *Pseudofusarium*, typified by *P. fusarioideum* Matsushima, but later (1975) identified this species with *F. semitectum*, and made the recombination *Pseudofusarium semitectum*. His illustrations show typical mesoconidiophores and mesoconidia but he did not observe macroconidia. Most of the above descriptions of *F. semitectum* (with the exception of Matsushima) were based on rich media such as PDA and OMA. On carnation leaf agar incubated under NUV light sporodochia are frequently formed on the carnation leaf pieces and the macroconidia produced are typical pedicellate macroconidia. Hughes (1953) described the ontogeny of *Fusarium* macroconidia using *F. semitectum* as an example, and this has been widely used as evidence that the first conidium from a phialide is holoblastic while those following are

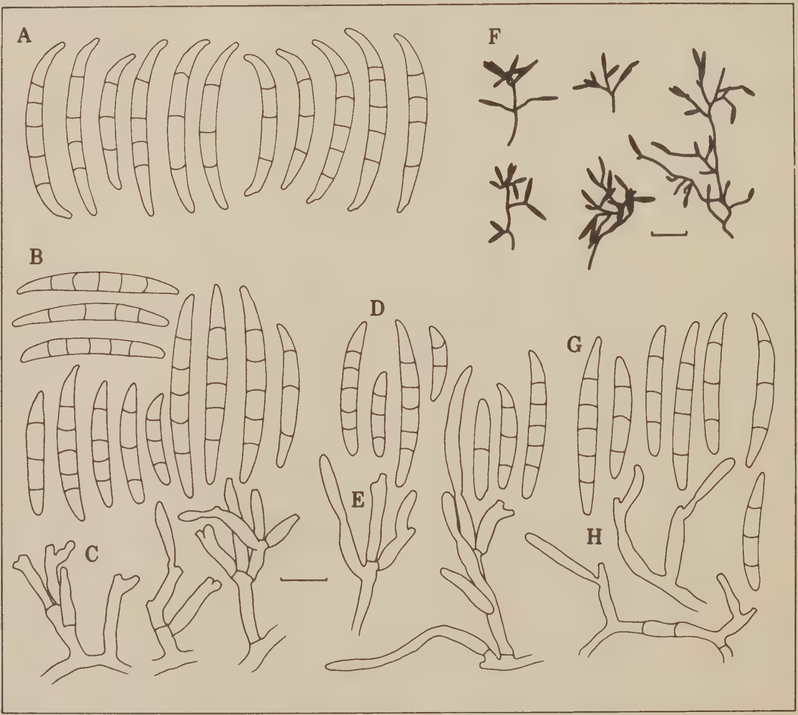

Fig. 10. *F. pallidoroseum* (*F. semitectum*) (VPRI 12075) **A.** Macroconidia from sporodochia on CLA; **B.,C.** Mesoconidia and mesoconidiophores from CLA; **C.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch SNA; **G.,H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; C:10 μm, F:50 μm.

enteroblastic. It is possible that Hughes' observations were based on mesoconidia and that the holoblastic first conidium was in fact the only conidium produced from that conidiogenous locus.

Booth & Sutton (1984) mention sporodochia in *F. pallidoroseum* but Nelson, Tousson and Marasas (1983) and Burgess and Liddell (1983), are the only previous authors to acknowledge and illustrate the difference between macroconidia from sporodochia and spindle-shaped macroconidia from the aerial mycelium (mesoconidia). Macroconidia are also found sparsely in the aerial

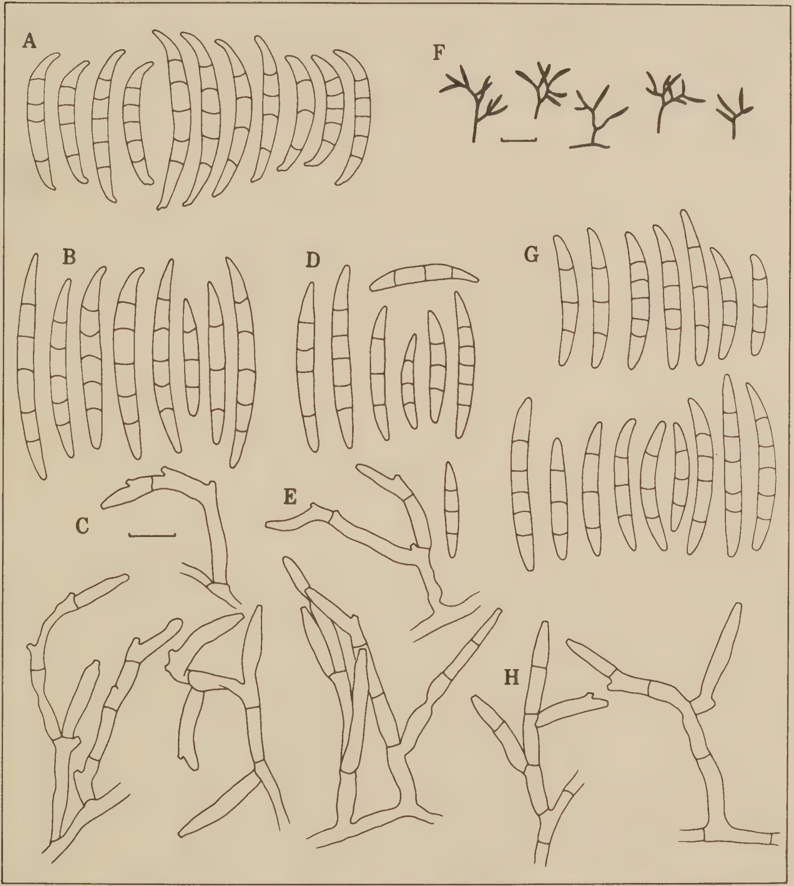

Fig. 11. *F. pallidoroseum* (*F. semitectum*) (VPRI 12003) **A.** Macroconidia from spore masses in the aerial mycelium on CLA; **B., C.** Mesoconidia and mesoconidiophores from CLA; **D., E.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch, SNA; **G., H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; C:10 μm, F:50 μm.

mycelium on PDA, CLA and SNA scattered amongst the mesoconidia in small slimy masses. Isolated mesoconidia can be distinguished from macroconidia by their greater width, weaker curvature, apedicellate basal cell and straighter apical cell. Mesoconidia are frequently longer than macroconidia.

The isolates of *F. pallidoroseum* studied show considerable diversity in mesoconidium and mesoconidiophore morphology. Conidiophores vary from short simple conidiophores arising from the agar surface (VPRI 11965, fig. 12), to very complex conidiophores produced wholly in the aerial mycelium (VPRI 12078, fig. 9). Mesoconidia in 11965 are mostly less than 40 um long, while in 12078 they are frequently more than 50 um long. Since the other two isolates (12003, 12076) are intermediate in conidium and conidiophore morphology it is unlikely that these differences have any taxonomic validity, although *F. semitectum* has previously been divided, the variety *majus* Wollenweber being separated on the basis of mesoconidium length. *F. diversiporum* Sherbakoff has been synonymised

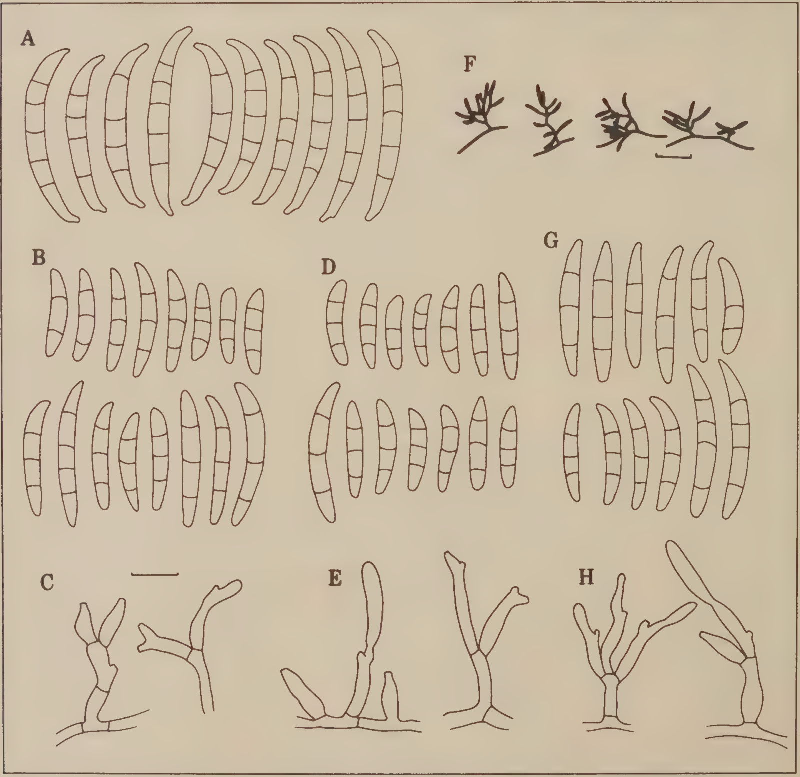

Fig. 12. *F. pallidoroseum* (*F. semitectum*) (VPRI 11965) **A.** Macroconidia from sporodochia on CLA; **B., C.** Mesoconidia and mesoconidiophores from CLA; **D., E.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch, SNA; **G., H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; C:10 μm, F:50 μm.

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with *F. semitectum* by Booth (1971) and others, but comparison of sporodochial macroconidia of the *F. pallidoroseum* isolates studied with a Sherbakoff specimen of *F. diversisporum* (CUP 7430) reveals that the two species are quite distinct (see comments on *F. avenaceum*).

***F. sporotrichioides* Sherbakoff** - One isolate studied (see fig. 13). PDA. Growth rate (radius) 47 mm, after 6 days at 20-25°C. Cultures in reverse pink with pale-red radial streaks. Aerial mycelium pink to orange, low, moderately dense. Sporulation abundant, macroconidia produced in small slimy orange masses, on the agar surface and in the aerial mycelium. Mesoconidia abundant in the aerial mycelium. Microconidia less abundant, scattered amongst the mesoconidiophores.
CLA. Pigment lacking. Orange sporodochia produced on carnation leaf pieces. Aerial mycelium abundant, bearing abundant mesoconidia and sparse microconidia on compact, branched conidiophores.
SNA. Pigment lacking, aerial mycelium sparse, macroconidia produced in slimy masses on agar surface, mesoconidia abundant on branched conidiophores throughout aerial mycelium, microconidia sparse.
Mesoconidiophore and mesoconidium morphology

Mesoconidiophores arise from the aerial mycelium and vary from simple lateral conidiogenous cells to macronematous conidiophores with a complex almost penicillate branching pattern. Conidiogenous cells proliferate sympodially, producing compact sympodulae with varying numbers of loci. The numbers of loci per conidiogenous cell appear to vary inversely with the complexity of the conidiophore: in complex conidiophores there are usually only 1-3 loci per cell, but in simple lateral conidiogenous cells there may be as many as six. After conidial secession a broad, flat, unthickened scar remains with an inconspicuous marginal frill. Mesoconidia are mostly falcate, occasionally straight and fusoid, 6-36 x 2.5-5 μm, 0-3-(5)-septate, mostly 3-septate, with a curved, bluntly pointed apical cell and a narrowly truncate basal cell (truncation 1-1.5 μm wide), 3-septate conidia 14-29.5 μm long.

Specimen examined:
VPRI 12049, isolated from Soybean seed, Lismore, N.S.W., L. W. Burgess, FRL 6777.

F. sporotrichioides is extremely uncommon in Australia, VPRI 12049 being the only Australian isolate available at the Sydney workshop, and the only isolate so far examined in detail by the author. *F. sporotrichioides* is one of the two species known to have macro-, meso- and microconidia, all of which may be produced simultaneously in the aerial mycelium. Whether the microconidia are strictly analagous to other microconidia in *Fusarium* is uncertain as they often appear to be produced from sympodially proliferating conidiogenous cells, and although accumulating in false heads are rather dry in appearance.

Macroconidia are also produced in the aerial mycelium (as well as in sporodochia), so it is sometimes difficult to determine which conidiogenous cells are responsible for which conidia. When macroconidia and mesoconidia are present on the same slide they are often difficult to distinguish, especially when macroconidia are inconspicuously pedicellate. In most previous publications on *F. sporotrichioides* (Gerlach & Nirenberg, 1982, Nelson, Tousson & Marasas, 1983, Seemuller, 1968) the fungus has been regarded as having macroconidia and two types of microconidia, (subglobose and fusiform). It is possible that those authors were classifiying the larger (3-5-septate) mesoconidia as macroconidia and the smaller (0-2-septate) mesoconidia as microconidia. It should be noted that sporodochial macroconidia of VPRI 12049 are considerably smaller than those illustrated by other authors, and that this isolate may possibly be atypical in other

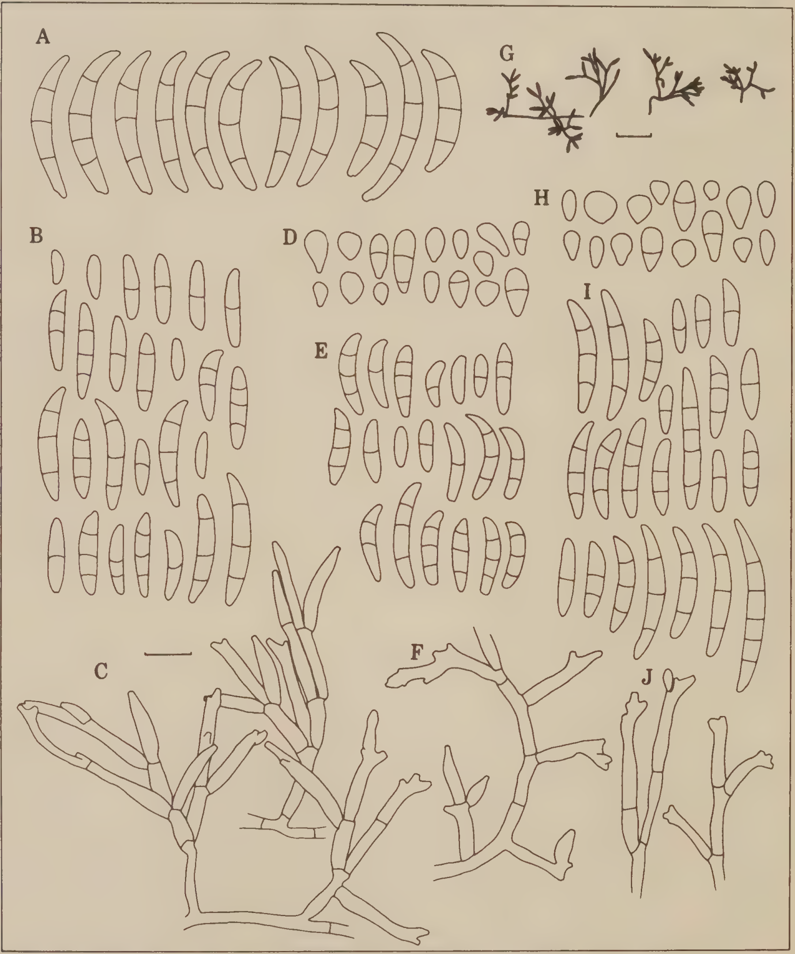

Fig. 13. *F. sporotrichioides* (VPRI 12049) **A.** Macroconidia from sporodochia on CLA; **B., C.** Mesoconidia and mesoconidiophores from CLA; **D.** Microconidia from PDA; **E., F.** Mesoconidia and mesoconidiophores from PDA; **G.** Habit sketch, SNA; **H.** Microconidia, SNA; **I., J.** Mesoconidia and mesoconidiophores from SNA. Scale bars; C:10 μm, G: 50 μm.

respects.

Neish (1982), in his description of *F. sporotrichioides*, published (as Figure 2) a scanning electron micrograph of a sympodially proliferating conidiogenous cell with a conspicuous collarette. Since there is a conidium attached to the conidiogenous locus bearing the collarette, it seems that more than one conidium has been produced and the conidiogenous cell cannot be a mesoconidiogenous cell. *F. sporotrichioides* does produce large numbers of macroconidia in the aerial mycelium and it is possible that Neish's illustration is of a polyphialidic macroconidiophore. His Figure 1 shows a sympodially proliferating conidiogenous cell without collarettes, which is much more like a mesoconidiogenous cell.

***Fusarium chenopodinum* (Thuem.) Sacc.** (*F. scirpi* Lamb. & Fautr. sensu Nelson et al. 1983, and Burgess et al. 1985). Three isolates studied (see Figs. 14-16).
PDA. Average growth rate (radius) after 6 days at 20-25°C, 47 mm (range 46-48). Cultures in reverse cream to pinkish buff. Aerial mycelium dense, felty, pink. Sporulation abundant with spore masses scattered through the aerial mycelium and abundant sporodochia developing centrally on the agar surface. Mesoconidia sparse and difficult to detect.
CLA. Pigment lacking. Large, deep orange sporodochia produced abundantly on carnation leaf pieces, and on agar. Aerial mycelium sparse to moderately dense, denser over carnation leaf pieces. Mesoconidia rather sparse but easily detected, produced mostly on simple lateral conidiogenous cells arising from the aerial mycelium.
SNA. Pigment lacking. Aerial mycelium sparse. Macroconidia produced in orange masses on agar surface. Mesoconidia sparse to moderately abundant, produced on simple, lateral conidiogenous cells.
Mesoconidiophore and mesoconidium morphology

Mesoconidiophores borne on the aerial hyphae, mostly as simple lateral conidiogenous cells bearing one to several conidia singly on sympodial proliferations. Occasionally two closely adherent conidia can be seen (fig. 2) especially close to the agar surface, but it is not clear whether these have developed from a single conidiogenous locus or from two closely adjacent loci. Branched conididiophores are uncommon. Conidiogenous cells mostly arise directly from the aerial hyphae, and are often not delimited by a basal septum. They proliferate sympodially, the apex bearing up to 7, although most often 2 or 3, denticular loci. In trilocular conidiogenous cells the arrangement of loci is frequently cruciate. Occasionally conidiogenesis is through a simple denticle borne directly on the hypha. Mesoconidia are long-ellipsoid to clavate, with a broadly rounded apical cell and truncate basal cell, 0-3-septate, most commonly 1-septate, 5-22 x 2-4 μm, the one-septate conidia 9-20.5 μm long, three-septate conidia 13.5-22 μm long.
Specimens examined: VPRI 12063, isolated from soil, Walgett, N.S.W., L. W. Burgess, FRL 5725; VPRI 12065, isolated from soil, Crookwell, N.S.W., L. W. Burgess, FRL 6710; VPRI 12067, isolated from soil, Walgett, N.S.W., L. W. Burgess, FRL 5722.

Fusarium chenopodinum is the only mesoconidial *Fusarium* so far encountered that belongs to *Fusarium* section *Gibbosum*, and its mesoconidia are quite distinct from those of the other species studied. Mesoconidia of *F. chenopodinum* are easily recognised by their clavate shape. The distinctive conidiophores consist mostly of single lateral conidiogenous cells with denticles spread at wide angles to one another. In other mesoconidial species, each conidiogenous denticle remains more or less parallel to the subtending cell, and it is the proliferation which is displaced to one side. In *F. chenopodinum* conidiogenous denticles appear to be displaced at right angles to the subtending cell. This raises some doubt as to whether proliferation is in fact sympodial, or whether conidia may be produced more or less synchronously. The conidiogenous locus is broad, and

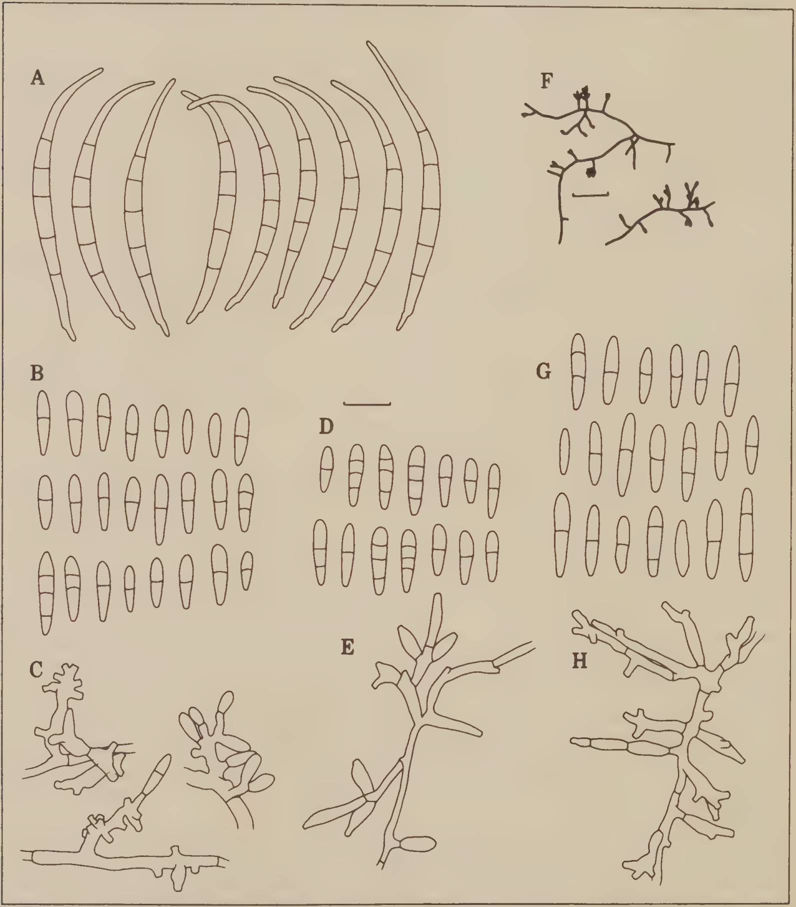

Fig. 14. *F. chenopodinum* (VPRI 12065) **A.** Macroconidia from sporodochia on CLA; **B.,C.** Mesoconidia and mesoconidiophores from CLA; **D.,E.** Meso-conidia and mesoconidiophores from PDA; **F.** Habit sketch SNA; **G.,H.** Mesoconidia and mesoconidiophores from SNA. Scale bars: D:10 μm, F:50 μm.

the apical frill surrounding the conidial scar is frequently conspicuous, resembling a short collarette. Typical monophialides are frequently found amongst mesoconidiogenous cells, and two conidia similar in shape to mesoconidia are often seen attached to what is apparently a single conidiogenous locus. This frequently occurs close to or on the agar surface. It is possible that under certain conditions, conidiogenous cells initially dedicated to producing mesoconidia become capable of enteroblastic proliferation and production of several conidia from a single conidiogenous locus. It is in *F. chenopodinum* that the distinctions

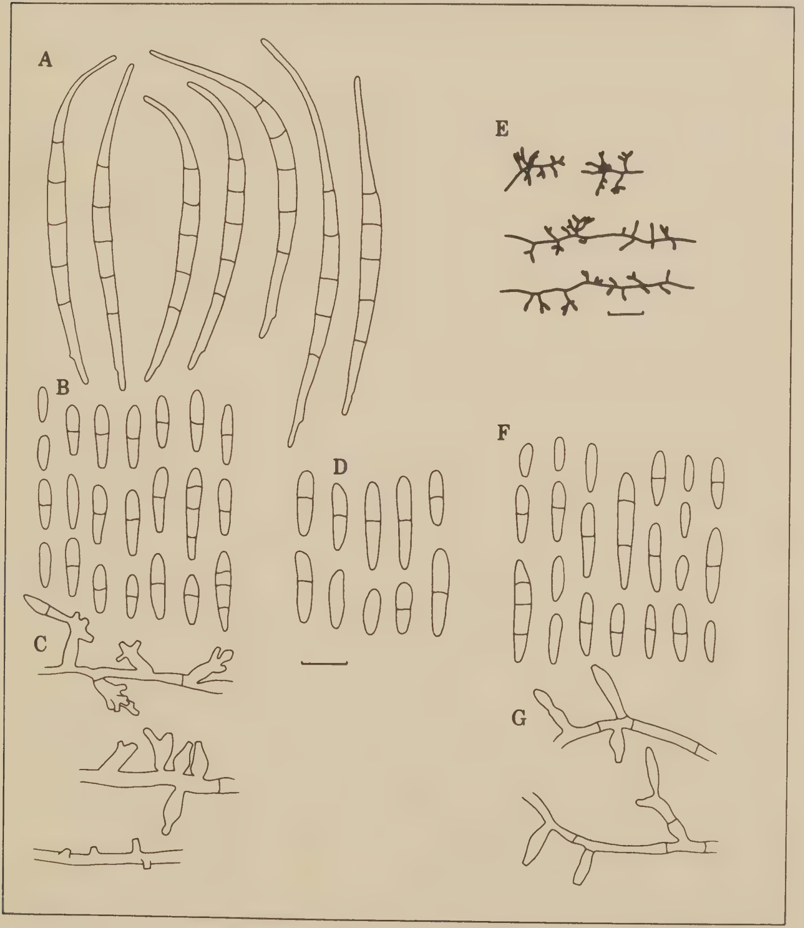

Fig. 15. *F. chenopodinum* (VPRI 12067) **A.** Macroconidia from sporodochia on CLA; **B.,C.** Mesoconidia and mesoconidiophores from CLA; **D.** Mesoconidia from PDA; **E.** Habit sketch, SNA; **F.,G.** Mesoconidia and mesoconidiophores from SNA. Scale bars; D:10 μm, E:50 μm.

between macro-, meso- and microconidia may become blurred.

Fusarium chenopodinum is abundantly illustrated by Wollenweber (1916-1935, Fus. autogr. del. Nos. 198, 199, 200, 201, 595), illustrations 199 and 200 apparently being of Thuemen's type specimen. Wollenweber's illustrations clearly show mesoconidia ("conidiis subnormalibus, 0-3-sept., 5-15 x 2.5-4 μm") and mesoconidiogenous cells similar to those illustrated here. Nelson, Tousson and Marasas (1983) and Burgess and Liddell (1983) provide excellent photographs of mesoconidia and mesoconidiophores of the same fungus. Burgess et al.(1985)

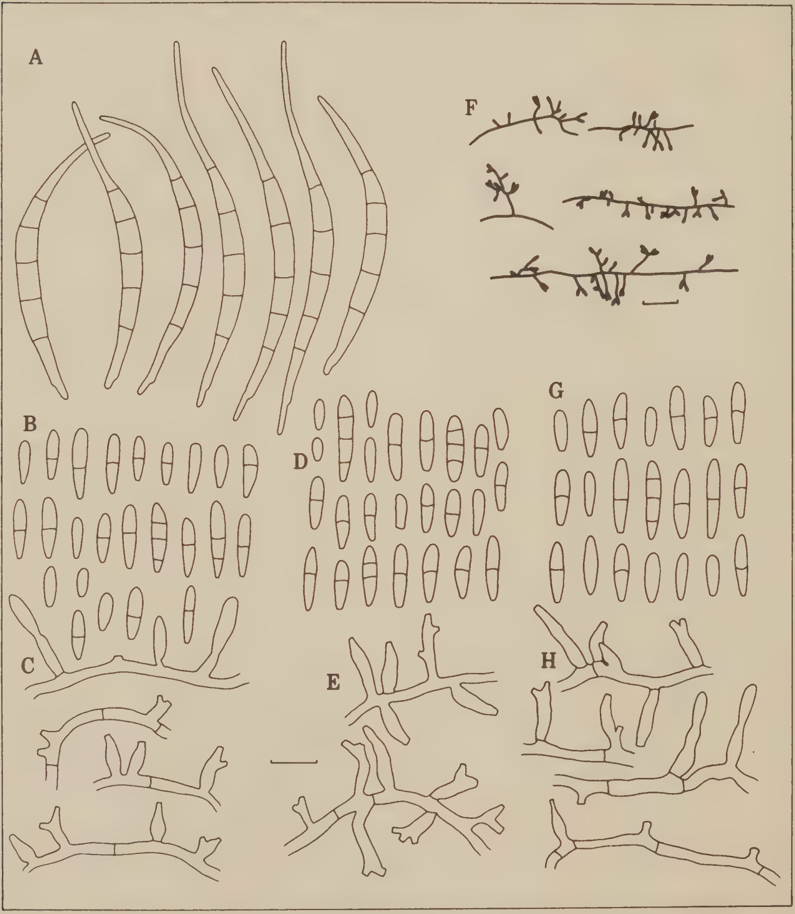

Fig. 16. *F. chenopodinum* (VPRI 12063) **A.** Macroconidia from sporodochia on CLA; **B., C.** Mesoconidia and mesoconidiophores from CLA; **D., E.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch, SNA; **G., H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; E:10 μm, F:50 μm.

and Nelson et al. (1983) have revived the name *F. scirpi* Lamb & Fautr., for the fungus and draw attention to Wollenweber's illustrations of *F. chenopodinum*. Their choice of *F. scirpi* is unfortunate since the epithet "*chenopodinum*" (Thuemen, 1879) clearly has priority over "*scirpi*" (Lambotte & Fautrey, 1894). A specimen in CUP (CUP 7434) supplied to Sherbakoff by Wollenweber as *F. gibbosum* Appel & Wollenw. is conspecific with *F. chenopodinum* so it is possible that *F. gibbosum* is also synonymous with *F. chenopodinum*. *F. chenopodinum* appears to be a good species, differing from *F. equiseti* by its paler colour on PDA, abundant production of deep orange sporodochia on all media, and characteristic mesoconidia. Many isolates identified as *F. equiseti* probably belong to this species.

***Fusarium chlamydosporum* Wollenw. & Reink.** 3 isolates studied. (see Figs. 17-19)
PDA. Average growth rate (radius) after 6 days at 20-25°C, 46 mm (range 43-49). Reverse pale to very dark carmine, aerial mycelium uniform, dense, rose to pink. Macroconidia not seen. Mesoconidia extremely abundant, giving the aerial mycelium a powdery appearance.
CLA. Pigment lacking in agar but aerial mycelium, especially over carnation leaf pieces, noticeably pink. Sporodochia formed on carnation leaf pieces in some isolates. Mesoconidia extremely abundant in aerial mycelium, forming dense digitate clusters on the ends of conidiogenous cells borne laterally or on compact branched conidiophores.
SNA. Pigment lacking. Macroconidia not seen. Aerial mycelium relatively sparse but bearing abundant mesoconidia, giving a powdery appearance to the aerial mycelium.
Mesoconidiophore and mesoconidium morphology

Mesoconidiophores extremely abundant in the aerial mycelium, varying from simple conidiogenous cells borne laterally on aerial hyphae to more complex, irregularly branched conidiophores. Mesoconidia produced singly from the numerous sympodial proliferations on each conidiogenous cell, and appearing as digitate clusters. Conidiogenous loci less than 1 μm wide, usually with a thickened apical wall with no apparent marginal frill. Conidia ellipsoid, rounded apically and tapered basally to a narrow (0.5 - 1.0 μm wide) truncation, 0-1-(3)-septate, 6-26 x 2-4 μm; the 0-septate conidia 6-15 μm long, 1-septate conidia 11-21 μm long and 3-septate conidia 18.5-26 μm long.
Specimens examined: VPRI 12000, isolated from seed of *Zinnia* sp., imported from Holland, 6 July, 1983, M. Lane; VPRI 12050, isolated from grassland soil, Longreach, Queensland, L. W. Burgess, FRL 6777; VPRI 12052, isolated from soil, Simpson Desert, Australia, L. W. Burgess, FRL 6660.

F. chlamydosporum (syn. *F. fusarioides* sensu Booth, 1971) is the most prolific producer of mesoconidia in the genus. The aerial mycelium on all media appears powdery with the large numbers of dry mesoconidia produced. Mesoconidia are predominantly non-septate, and mesoconidiogenous cells are compactly sympodial, often forming a kind of "fist" studded with denticles. One isolate (VPRI 12775) examined after the above description and illustrations were prepared, forms poorly developed synnemata composed of vertical aggregations of strongly carmine-pigmented hyphae, with conidiophores produced laterally along their lengths. Mesoconidia and mesoconidiophores of *F. chlamydosporum* are strongly reminiscent of the genera *Sporothrix* and *Calcarisporium* to which the fungus would undoubtedly have been assigned if not for its fast growth, deep red pigmentation and occasional macroconidia. Although most authors describe

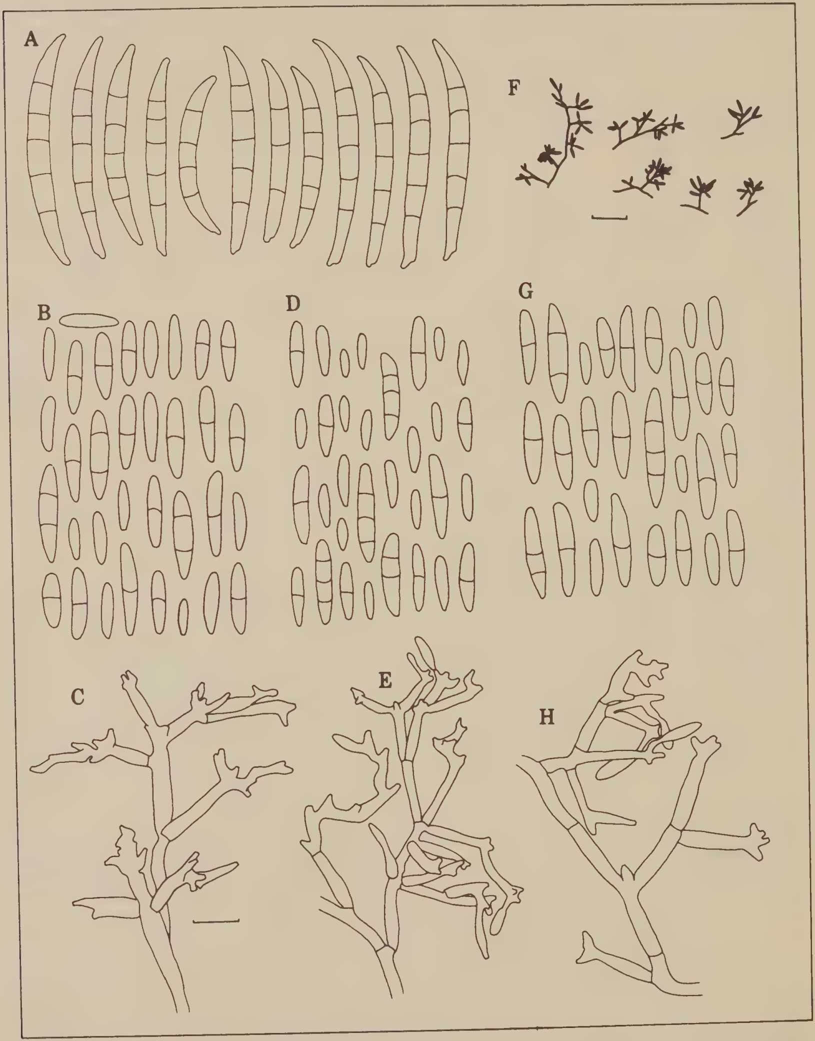

Fig. 17. *F. chlamydosporum* (VPRI 12052) **A.** Macroconidia from sporodochia on CLA; **B., C.** Mesoconidia and mesoconidiophores from CLA; **D., E.** Mesoconidia and mesoconidiophores from PDA; **F.** Habit sketch, SNA; **G., H.** Mesoconidia and mesoconidiophores from SNA. Scale bars; C:10 μm, F:50 μm.

macroconidia, these were only produced by one of the isolates studied (VPRI 12052). This isolate also produced a higher proportion of septate mesoconidia than the other isolates. The 0-septate mesoconidia of *F. chlamydosporum* closely resemble the microconidia of the chain-forming *Liseola* species, and have been called microconidia by all previous authors. However, despite their morphological resemblance to microconidia, their habit, ontogeny and conidiophore morphology, plus the occurrence of occasional 2-3-septate conidia similar to the mesoconidia of other species, fully justifies the inclusion of *F. chlamydosporum* amongst the mesoconidial Fusaria.

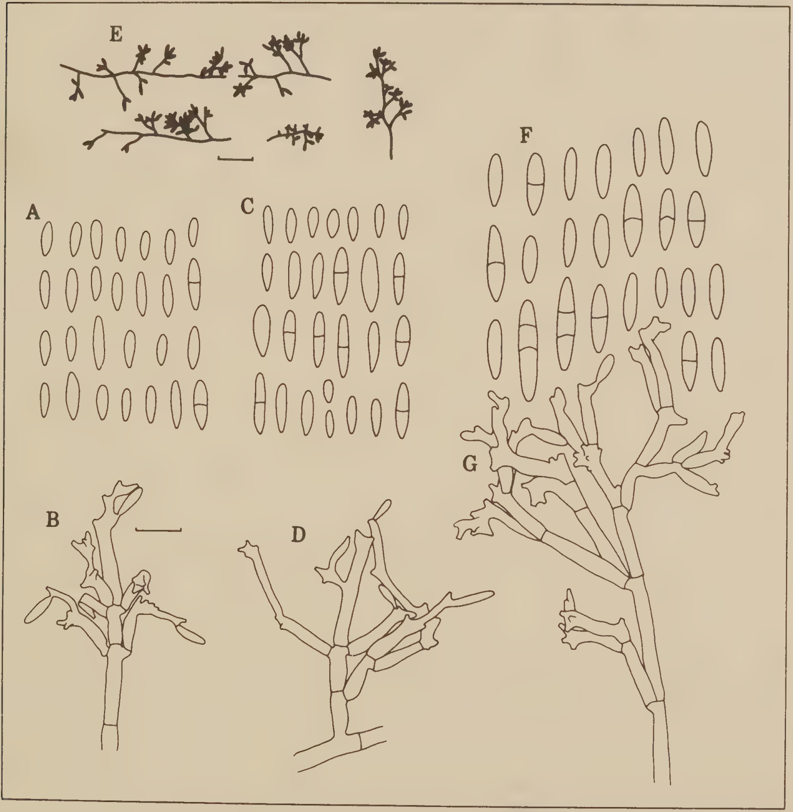

Fig. 18. *F. chlamydosporum* (VPRI 12000) **A.,B.** Mesoconidia and mesoconidiophores from CLA; **C.,D.** Mesoconidia and mesoconidiophores from PDA; **E.** Habit sketch SNA; **F.,G.** Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, E:50 μm.

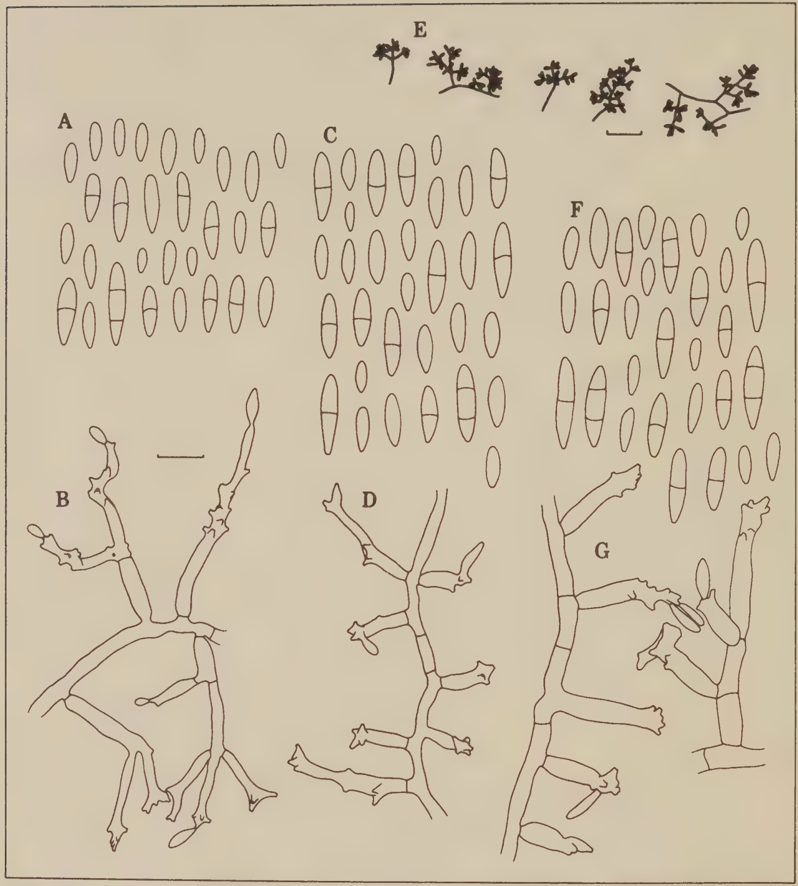

Fig. 19. *F. chlamydosporum* (VPRI 12050) **A., B.** Mesoconidia and mesoconidiophores from CLA; **C., D.** Mesoconidia and mesoconidiophores from PDA; **E.** Habit sketch from SNA; **F., G.** Mesoconidia and mesoconidiophores from SNA. Scale bars; B:10 μm, E:50 μm.

Fusarium subglutinans **(Wollenw. & Reinking) Nelson, Tousson & Marasas**. One isolate studied (VPRI 12816),(see Fig. 20)

PDA. Growth rate (radius) 29 mm after 6 days at 25°C. Cultures in reverse initially pale buff, darkening to various shades of purple with blueish tinges in NUV (reddish tinges in natural diffuse daylight or darkness). Aerial mycelium white with greyish purple tinges, becoming powdery with production of abundant conidia. Macroconidia sparse, confined to the agar surface. Microconidia and mesoconidia abundant in the aerial mycelium, microconidia predominating.

CLA. Pigment lacking. White sporodochia, becoming orange, produced sparsely on the carnation leaf pieces, after 2 weeks. Aerial mycelium sparse, consisting almost entirely of complex, branched conidiophores bearing abundant mesoconidia and microconidia.

SNA. Pigment lacking. Macroconidia sparse and confined to small masses on the agar surface. Aerial mycelium sparse and powdery in appearance, consisting almost entirely of complex branched conidiophores bearing abundant mesoconidia and microconidia.

Mesoconidiophore and mesoconidium morphology

Conidiophores arise from the agar surface as complex branched structures bearing single mesoconidia or false heads of microconidia at the ends of each branch or sympodial proliferation. Mesoconidia and microconidia are produced together on the same conidiophores, but mesoconidia tend to be more abundant apically, while microconidia predominate towards the base of the conidiophore. The relative abundance of microconidia and mesoconidia is determined by growth medium and light (see Pascoe, 1990). PDA produces relatively fewer mesoconidia than microconidia even under NUV lighting while the weaker media (CLA, SNA) produce more mesoconidia than microconidia under NUV but mainly microconidia in darkness. There is also a tendency for mesoconidia and microconidia to intergrade under certain conditions. On rich media or under suboptimal light conditions conidiogenous cells are often seen to have produced either a single mesoconidium followed by several microconidia, or several conidia which are intermediate in size between mesoconidia and microconidia but which do not qualify as either.

Mesoconidiogenous cells cannot be distinguished morphologically from microconidiogenous cells. They proliferate sympodially and the proliferation frequently grows on to produce numerous further conidiogenous cells with several intervening septa. Seccession of conidia from a sympodially proliferating conidiogenous cell leaves a denticle 2-3 μm long with a flat to slightly rounded unthickened apex and an inconspicuous marginal frill. Microconidiogenous cells are similar in appearance and do not closely resemble classical phialides of other microconidial Fusaria. Mesoconidia are straight or slightly curved, fusiform to lanceolate, 16-43 x 3-4.5 μm, with a bluntly pointed, often slightly asymmetrical apical cell and truncate basal cell (the truncation about 1μm wide). Under optimum conditions, 3-septate conidia of about 24-28 μm in length are most common.

Specimen examined:

VPRI 12816, isolated from seed of *Zea mays*, East Gippsland, Victoria, 15 July, 1985, M. Mebalds.

F. subglutinans is a well known and economically important taxon, for which several names are in common use. Booth (1971) called the fungus *F. moniliforme* Sheldon var. *subglutinans* Wollenw. & Reinking while Nirenberg (1976) called it *F. sacchari* var. *subglutinans*. I have followed Nelson et. al. (1983) in using the epithet as a species name simply for the convenience of having a simple binomial for the fungus, without necessarily endorsing the elevation of the taxon to specific rank. Burgess and Liddell (1983) describe *F. subglutinans* as having "longer microconidia (transitional macroconidia?) which are spindle-shaped, 2-3 septate" and which "resemble the spindle-shaped conidia of *F. semitectum*". Their illustration (as fig. 18E) shows mesoconidia similar to those described herein. Nelson et. al. (1983) also mention 1-3-septate microconidia and their fig. 54(b) shows good mesoconidia. Nirenberg (1976) also mentions 1-, 2- and 3-septate microconidia as a transitional phase to macroconidia and illustrates a few mesoconidia in her illustration of microconidia.

It is possible that there may be two taxa concealed under the epithet *subglutinans*, one with mesoconidia and one without. However, it is more likely that production of mesoconidia is not sufficiently reliable to allow such a

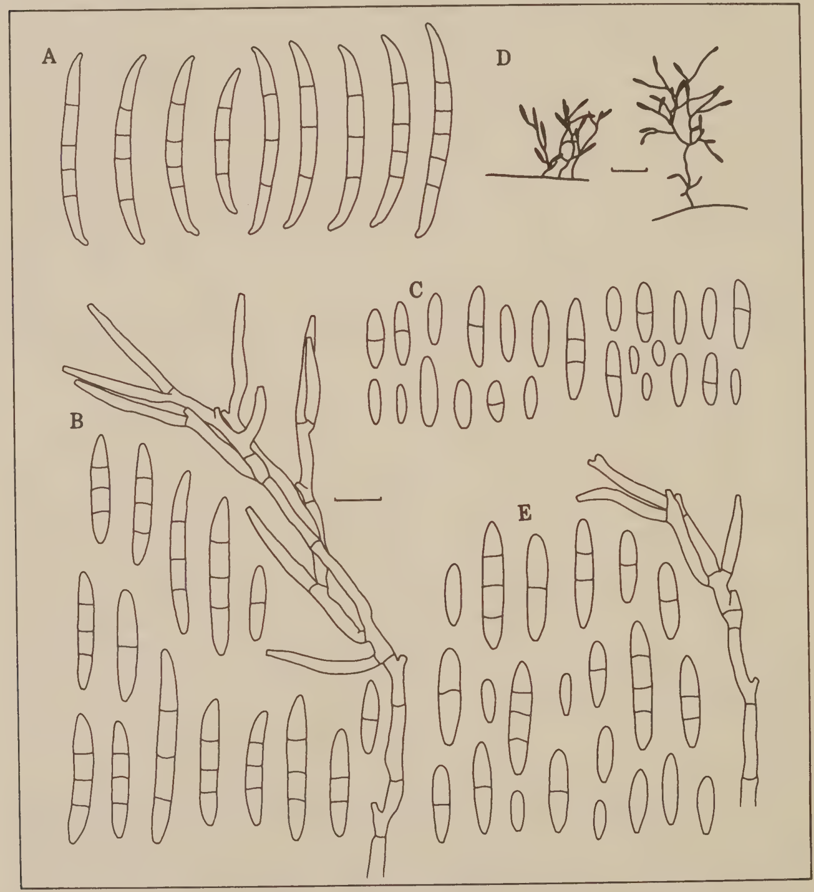

Fig. 20 *F. subglutinans* (VPRI 12816) **A.** Macroconidia from sporodochia on CLA; **B.** Mesoconidiophores and mesoconidia from CLA; **C.** Mixed microconidia and mesoconidia from PDA; **D.** Habit sketch, SNA; **E.** Mixed microconidia and mesoconidia from SNA. Scale bars; B:10 μm, D:50 μm.

distinction to be made. One other isolate of *F. subglutinans* (VPRI 12829) has been seen which has much less definitive mesoconidia than VPRI 12816, to the extent that its production of mesoconidia on CLA under NUV lighting is no more reliable than that of VPRI 12816 on richer media or in normal daylight.

F. subglutinans is the only mesoconidial *Fusarium* from *F.* sect. *Liseola* and, apart from *F. chenopodinum*, the only mesoconidial species to fall outside of Booth's concept of *F.* sect. *Arthrosporiella*. Nevertheless if one were to group the species studied in this paper on the basis of morphology of mesoconidia and mesoconidiophores alone, then *F. subglutinans* would be seen to be most closely related to, and almost indistinguishable from *F. avenaceum*.

DISCUSSION

The foregoing descriptions and illustrations should make it clear that mesoconidia are common and characteristic in a number of *Fusarium* species. With experience it is possible to recognise tentatively these species on the basis of mesoconidial habit alone, and to confirm this by consideration of cultural characteristics, macroconidial morphology and mesoconidium and mesoconidiophore morphology. The principal differentiating features of mesoconidia of these six species are summarised in Table 2.

Table 2. Morphology of mesoconidia from six *Fusarium* species.

Name	Loci per conidiogenous cell	Common Septation	Length (μm)	Shape
F. avenaceum	1-2 (3)	3-5	15-40	straight, fusiform.
F. pallidoroseum	1-2 (3)	3-5	15-47	curved, falcate.
F. sporotrichioides	2-3	1-3	14-30	curved, falcate.
F. chenopodinum	1-6	0-1(3)	5-22	straight, clavate.
F. chlamydosporum	2-10	0-1(3)	6-22	straight, fusoid.
F. subglutinans	1-2	1-3	16-43	straight, fusoid.

The term "mesoconidium" is proposed simply because of a perceived need for a term to cover spindle-shaped conidia produced singly in the aerial mycelium, which have not been easily accommodated by the terms "microconidia" and "macroconidia". No more profound significance than that should be attributed to the term. This is not the first time that attention has been drawn to such conidia; this paper merely recognises the functional and morphological similarity between such conidia in different species, and by proposing and defining the term "mesoconidium" also more precisely defines the terms "macroconidium" and "microconidium", and overcomes the terminological confusion surrounding mesoconidia in *Fusarium* literature (see Table 3). Mesoconidia appear not to have any broad infrageneric significance, but may simply represent a useful morphological criterion for species differentiation. Mesoconidia may not be absolutely analagous across the range of species in which they occur. The principal criterion for identifying mesoconidia is that they are produced singly in the aerial mycelium. Supplementary criteria which may not be universal include conidiogenous cells which proliferate sympodially, at least some (usually most) conidia septate, and a narrowly truncate basal cell without a lateral appendage. In morphological and functional terms microconidia of the chain-forming Liseola species may be more closely analagous to mesoconidia than they are to the microconidia of *F. oxysporum* but the principal differential criterion of conidia produced either singly or in a basipetal series dictates that they be regarded as microconidia.

Mesoconidia may not be restricted to the species described herein and indeed all species may produce small numbers of conidia which fit the definition of mesoconidia, just as most species appear to produce small numbers of microconidia. It is only when mesoconidia are produced abundantly and reliably that, as with all other morphological features, they can be used as taxonomic characters.

Within the genus *Fusarium*, macroconidia must be regarded as the definitive spore form. Some species produce only macroconidia but even among those species some conidia can usually be found which resemble microconidia. Of course there will always be some conidia which do not conform well with the defined concepts of macroconidia, mesoconidia or microconidia, and some species will produce these conidia in abundance. Isolates of *F. solani* show a continuum between microconidia and macroconidia, with false heads on elongated phialides containing a range of conidia from ellipsoid, unicellular classical microconidia to 3-septate, falcate macroconidia. Some isolates of *F. equiseti* produce small numbers of single, septate conidia in the aerial mycelium which by definition could be mesoconidia. However these conidia are usually similar in shape to macroconidia, they are broadly truncate at the base, with the width of the truncation equalling that of the subtending hypha, and they often have a very small lateral appendage. These conidia are best regarded as abortive macroconidia.

In other species the production of macroconidia is relatively rare and apparently dependent on particular environmental or nutritional conditions. *F. pallidoroseum*, *F. chlamydosporum* and apparently *F. camptoceras* are predominantly mesoconidial, and cannot be relied upon to produce macroconidia. In *Fusarium* section *Liseola* production of macroconidia may be infrequent while microconidia are produced in abundance. Some isolates of *F. equiseti* produce extremely abundant chlamydospores and very few macroconidia. In those species in which production of macroconidia is sparse or unreliable, a case can often be made for regarding the other spore forms (micro- or mesoconidia, or chlamydospores) as presenting distinct ecological advantages over macroconidia (assuming such an extrapolation from artificial culture to host material in natural habitats is warranted).

The mesoconidial species and the chain-forming *Liseola* species may be

Table 3. Terminology used by some modern authors for mesoconidia and mesoconidiophores.

	F. avenaceum	*F. semitectum*	*F. sporotrichioides*	*F. subglutinans*	*F. chlamydosporum*
Seemuller (1968)	–	–	microconidia "Hughes sect. II"	–	microconidia "Hughes sect. II"
Booth (1971)	primary macro. polyblastic	primary macro. polyblastic	microconidia blastic sympodial	–	microconidia blastic
Domsch et al. (1980)	primary conidia polyphialidic	macroconidia phialidic/sympodial	microconidia phialidic/sympodial	–	microconidia phialidic/sympodial
Samson et al. (1981)	microconidia polyblastic	macroconidia polyblastic	microconidia phialidic/sympodial	–	–
Nirenberg (1981)	primary micro. blastic	–	primary micro blastic	–	–
Gerlach & Nirenberg (1982)	primary conidia blastic or phialidic sympodial	conidia phialidic	microconidia primary c/phores polyblastic	microconidia (transitional macro.) polyphialidic	microconidia primary c/phores polyblastic
Nelson et al. (1983)	microconidia branched monophialidic	macroconidia polyphialidic	microconidia polyphialidic	microconidia polyphialidic	microconidia polyphialidic

regarded as having developed conidia to aid in air-dispersal of inoculum, in some cases almost to the exclusion of splash-dispersed macroconidia (Pascoe, 1990). Of course some species (such as *F. sporotrichioides*) have retained their versatility by producing macroconidia, microconidia and mesoconidia with equal reliability. *F. subglutinans*, which, unlike the other important Liseola species, does not produce microconidia in chains, appears to have compensated for this disadvantage in terms of air-dispersal by producing mesoconidia.

Fusarium chenopodinum is the species in which mesoconidia cause most difficulties in interpretation. Although the majority of mesoconidia are single, classical mesoconidia, pairs of conidia (occasionally three) are produced amongst the mesoconidia (Fig. 2). These conidia are morphologically identical to single mesoconidia and are produced from identical conidiogenous cells. Although they do not conform with the definition of mesoconidia, they also do not conform with the definitions of microconidia or macroconidia. Because they are so similar in appearance to mesoconidia, they may be regarded as mesoconidia in which the conidiogenous cell has continued to produce conidia instead of stopping after the first one. These conidiogenous cells usually have only one conidiogenous locus and it is possible that they have produced several conidia through one conidiogenous locus as an alternative to producing several denticular loci each with a single conidium.

A similar flexibility in mesoconidium production has occasionally been observed in other species. In *F. pallidoroseum*, mesoconidia are occasionally seen in pairs, and these are assumed to have been produced by the same conidiogenous cell. Conidiogenous cells have been seen very rarely which appear to be annellidic. In *F. avenaceum*, single mesoconidia have been seen attached to single macroconidia in the aerial mycelium. In such cases it is obvious that the mesoconidium has been produced first as the macroconidium is still attached to the conidiogenous cell, so it appears that after producing a mesoconidium the conidiogenous cell has proliferated and produced a macroconidium. Percurrent proliferation of conidiogenous cells with formation of a prominent apical collarette has been seen amongst mesoconidiogenous cells (see Fig. 3B) and these are regarded as evidence of occasional proliferation of mesoconidiogenous cells to produce macroconidia. In the isolate of *F. subglutinans* studied, after several subcultures, conidiogenous cells were frequently seen to produce a mesoconidium followed by several smaller conidia which were intermediate in morphology between microconidia and mesoconidia. Such morphological flexibility should not be surprising in a genus renowned for its variability and should not cause serious problems providing the definitions proposed in this paper are used judiciously.

Careful examination of the *Fusarium* literature reveals many instances where conidia resembling mesoconidia have been described or illustrated. Sherbakoff (1915) drew attention to 1-, 2- or 3-septate conidia which were a different shape from microconidia and which were borne singly giving the aerial mycelium a powdery appearance. He defined the section *Arthrosporiella* as having such conidia and described and illustrated non-pedicellate, septate conidia, in some cases borne on sympodially proliferating conidiogenous cells, in *F. diversisporum*, *F. anguioides*, *F. arthrosporioides*, *F. sporotrichioides* and *F. trichothecioides*. Wollenweber (1916-1935), and Wollenweber & Reinking (1935) describe or

Wollenweber (1916-1935), and Wollenweber & Reinking (1935) describe or illustrate conidia which may be interpreted as mesoconidia for *F. chenopodinum*, *F. chlamydosporum*, *F. sporotrichioides*, *F. arthrosporioides*, *F. semitectum*, *F. camptoceras*, *F. diversisporum*, *F. concolor*, *F. anguioides*, *F. equiseti* var. *bullatum* and *F. scirpi*. Booth (1971) described holoblastic sympodial macro- or microconidia for *F. avenaceum*, *F. semitectum*, *F. fusarioides*, *F. sporotrichioides* and *F. camptoceras*. Gerlach and Nirenberg (1982) illustrate or describe 0-3-septate microconidia, or abnormal apedicellate macroconidia with (in most cases) blastic or polyblastic conidiogenesis for *F. sarcochroum*, *F. stilboides*, *F. anguioides*, *F. concolor*, *F. camptoceras*, *F. semitectum*, *F. arthrosporioides*, *F. detonianum*, *F. avenaceum*, *F. sporotrichioides* and *F. chlamydosporum*. Nelson, Tousson and Marasas (1983) describe or illustrate spindle-shaped, apedicellate, 0-3-septate conidia as microconidia for *F. sporotrichioides*, *F. chlamydosporum*, *F. avenaceum*, *F. scirpi* and *F. subglutinans*, and as macroconidia for *F. semitectum*, *F. camptoceras* and *F. diversisporum*.

Some of the above species are possibly synonymous with species discussed in detail in this paper, but others merit further investigation for the occurrence of mesoconidia. *F. camptoceras* is almost certainly mesoconidial but no description so far seen has included macroconidia. The fungus has not been widely studied and perhaps examination of enough isolates under appropriate conditions could result in the production of sporodochial macroconidia.

Mesoconidia do not appear to have much significance as sectional criteria in *Fusarium*. Booth's (1971) classification included five mesoconidial species in *F.* section *Arthrosporiella*, but subsequent discovery of *F. chenopodinum* (*F.* sect. *Gibbosum*) and *F. subglutinans* (*F.* sect. *Liseola*) as mesoconidial species suggests that mesoconidia are not adequate as sole sectional criteria. Although it has been pointed out that *F. chenopodinum* mesoconidia differ in several respects from those of other species, the mesoconidia of *F. subglutinans* appear to be exactly analagous to those of other species. There is little doubt that *F.* sect. *Liseola* represents a distinct and homogenous group, and that *F. subglutinans* belongs firmly in that group.

It is probable that other hyphomycete genera characterised by holoblastic, hyaline, septate conidia and sympodially proliferating conidiogenous cells contain unrecognised *Fusarium* species. Matsushima's (1975) *Pseudofusarium fusarioides* has already been mentioned as mesoconidial *F. pallidoroseum* and it is possible from his illustrations that *Pseudofusarium purpureum* Matsushima is also a mesoconidial *Fusarium*, most probably *F. chlamydosporum*.

Several other genera including *Sympodiophora*, *Pseudohansfordia*, *Dactylaria* and *Calcarisporium* have similar conidiogenesis and conidia to *Fusarium* mesoconidia. *Sympodiophora venezuelensis* Deighton & Pyrozinski (1972) is regarded as a synonym of *F. pallidoroseum* by Booth & Sutton (1984). Several other *Sympodiophora* species described by Deighton and Pyrozinski may also be mesoconidial Fusaria. It would be interesting to grow these species on CLA under near-ultraviolet light in an attempt to induce formation of sporodochial macroconidia. Cole and Samson (1979, figs. 3.47, 3.48) illustrate conidiophores of *Sympodiophora* as seen under the scanning electron microscope, and these conidiophores closely resemble those of *Fusarium* mesoconidia. De Hoog (1978) places some species of *Sympodiophora* in *Pseudohansfordia* and comments that this genus differs only slightly from *Pseudofusarium* Matsushima and that several taxa of *Fusarium* sect. *Arthrosporiella* sensu Booth are closely related.

Mesoconidiogenesis agrees well with generally accepted concepts of holoblastic, sympodial conidiogenesis. Although conidiogenesis in *Fusarium* has traditionally been regarded as exclusively phialidic, many authors have described conidiogenesis in some species as holoblastic. These authors were invariably referring to mesoconidia. Other authors however, prefer to use the term "phialidic" for all conidiogenesis in *Fusarium*. It is difficult to be dogmatic on this point as the term "phialide" undeniably covers a heterogeneous assemblage of conidiogenesis types (Minter et al. 1983) but the phialide is universally regarded as a cell which produces a basipetal succession of conidia, and the term cannot be applied to mesoconidiogenous cells. Little is known of the process of conidiogenesis in *Fusarium* and few studies of the detailed anatomy of conidiogenous cells have been published, the most revealing being that of Schneider and Seaman (1982) on macroconidia of *F. sulphureum*. Similar electron microscope studies on the ontogeny of mesoconidia are needed. Initial light microscopic observations of conidiogenous cells of macroconidia, microconidia, and mesoconidia reveal a remarkable diversity in the anatomy of conidiogenous loci, both between species and isolates and within isolates of a given species. Mesoconidiogenous cells mostly lack a collarette, (although there may be an abbreviated marginal frill), and often have wall material occluding the apex of the cell. This is most clearly seen when effete conidiogenous cells are examined. In the absence of cytoplasm, the apex of a mesoconidiogenous cell is seen to be closed, whereas in a macroconidiogenous cell the apex is seen to remain open. This suggests that mesoconidia are produced singly because the delimiting septum is sufficiently hard to prevent further growth through the apex of the conidiogenous cell. Macroconidia and slimy microconidia presumably do not have a rigid delimiting septum and conidia continue to be produced until the conidiogenous cell and its supplying hyphae are exhausted. It is interesting in this context that the sympodially proliferating conidiogenous cells producing microconidia in chains and clumps in *Fusarium* sect. *Liseola* are morphologically much more similar to mesoconidiogenous cells than to micro- or macroconidiogenous cells in other species. The ability of conidia to be detached by vibration and dispersed by air movement is apparently related to production by a conidiogenous cell without a conspicuous collarette or abundant cytoplasmic mucilage and with a reasonably rigid delimiting septum. Microconidia of section Liseola have truncate bases indicating a rigid delimiting septum, whereas microconidia of other species such as *F. oxysporum* and *F. solani* have rounded bases indicating gradual hardening of the basal wall without formation of a rigid delimiting septum.

It is hoped that recognition and characterisation of mesoconidia will provide *Fusarium* taxonomists with an additional useful morphological criterion and that differentiation of mesoconidia from macroconidia and microconidia will increase the accuracy with which all three types of conidia are used as morphological criteria.

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FUSARIUM MORPHOLOGY II: EXPERIMENTS ON GROWING CONDITIONS AND DISPERSAL OF MESOCONIDIA.

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SUMMARY:

Experiments on media and growing conditions for production of mesoconidia by *Fusarium* species, show that mesoconidia are produced most abundantly in weak (low sugar) media with lowered osmotic water potential, achieved by addition of potassium chloride to agar. Carnation leaf agar amended with 8 g/l KCl was superior to Nirenberg's Special Nutrient Agar (SNA) with respect to production of mesoconidia and sporodochial macroconidia. Light regimes also affected the production of mesoconidia, with most species responding to fluorescent lighting at near-ultraviolet wavelengths. Mesoconidia were generally inhibited by incubation in darkness. Morphology of mesoconidia was also affected by light regimes; in some species mesoconidia were up to 10-15 μm longer in near-ultraviolet light than in darkness. Mesoconidia were shown to be capable of liberation by vibration and dispersal by air currents, as were microconidia of *F. subglutinans* and *F. moniliforme*.

INTRODUCTION

Earlier work on the morphology of a third type of *Fusarium* conidium, the mesoconidium (Pascoe, 1990), resulted in the observation that mesoconidia were more abundantly produced on some media than on others, that production of mesoconidia was affected by light, and that mesoconidia were dry in appearance and were easily dislodged from conidiophores during collection of conidiophores from cultures for examination. This paper describes attempts to develop media and growing conditions to improve the reliability of production of mesoconidia without diminishing the usefulness of other morphological characters, and describes observations on the mechanism of dispersal of mesoconidia.

Fusarium species have traditionally been grown on carbohydrate-rich media such as potato dextrose agar (PDA), potato sucrose agar (PSA) and oatmeal agar (OMA). These media give rapid growth rates, abundant pigment production and often characteristic cultural morphology. However these media do not reliably produce sporodochia, uniform macroconidia or characteristic mesoconidia, in a wide range of species. Alternative media have been developed in an attempt to overcome these deficiencies in the rich media.

Carnation leaf agar (CLA) is described by Fisher et al. (1982) as a medium which promotes good vegetative growth (without excessive aerial mycelium), and reliable production of sporodochia and uniform macroconidia. They also stated that direct observation of CLA cultures under the compound microscope indicates the manner in which conidia are borne on conidiophores. Their illustration in support of this statement shows mesoconidia of an unknown species.

According to Nirenberg (1976, 1981) special nutrient agar (SNA) stimulated the development of microconidia in the aerial mycelium, and in combination with near-ultraviolet light, induced the formation of uniform macroconidia in sporodochia. Her (1981) illustrations of *F. avenaceum* (Fr.) Sacc. and *F. sporotrichioides* Sherbakoff show mesoconidia similar to those illustrated for these species by Pascoe (1990).

Work on the morphology of mesoconidia from six *Fusarium* species (Pascoe, 1990) compared mesoconidia produced on PDA, CLA and SNA and showed that PDA was unsuitable for production and observation of mesoconidia of some species. In *F. avenaceum*, mesoconidia were seldom produced on PDA, and because of the density of pigmentation and aerial mycelium were difficult to detect when they were produced. In *F. pallidoroseum* (Cooke) Sacc. (*F. semitectum* auct.) and *F. chlamydosporum* Wollenw. & Reinking, mesoconidia were produced abundantly on PDA but macroconidia were either not produced or were not produced in sporodochia, leading to difficulties in differentiation of macroconidia and mesoconidia, and to extreme variability in macroconidial morphology. In other species mesoconidia were produced in reasonable abundance but difficulties in observation still occurred on PDA in comparison with CLA and SNA. CLA and SNA both produced easily observed mesoconidia of all species but in those species where mesoconidia were less abundant (e.g. *F. avenaceum*) SNA was often superior to CLA. However it has been found (Pascoe, unpublished) that CLA is superior to SNA in production of sporodochia of a wide range of species. It is the carnation leaf pieces in CLA that stimulate production of sporodochia, while the water agar component produces mesoconidia with or without carnation leaf pieces. If the water agar component of CLA could be made to produce mesoconidia as abundantly as SNA, without diminishing the superiority of CLA over SNA with respect to sporodochium production, then CLA would be a much more versatile medium.

At the time of writing I have not had the opportunity of growing mesoconidial Fusaria on Hocking and Andrews' (1987) Dichloran chloramphenicol Peptone Agar, (DCPA) but their observations would indicate that CLA is superior to DCPA with respect to production of mesoconidia.

Hsieh et al. (1979) and Fisher et al. (1983) showed that the formation of microconidial chains in species of *Fusarium* sect. *Liseola* was affected by osmotic water potential of culture media. They added potassium chloride to water agar and found that longer and more abundant microconidial chains were produced than on plain water agar. Since microconidia produced in chains in *F. moniliforme* are apparently adapted to air dispersal (Hsieh et al., 1979, Ooka and Kommedahl, 1977) it seems that the artificial production of dry conditions (lowered osmotic water potential) by addition of KCl to agar may have stimulated the production of longer microconidial chains for more efficient air dispersal. Mesoconidia are dry conidia with an obvious potential for air-dispersal, so it is reasonable to expect that lowered osmotic water potentials in agar media might also stimulate mesoconidium production. Experiments involving manipulation of osmotic water potential by addition of potassium chloride to CLA and SNA are described herein.

It is generally accepted (Booth, 1971, Nelson et al., 1983, Burgess and Liddell, 1983) that near-ultraviolet light (NUV) is useful for ensuring production of sporodochial macroconidia. During work on mesoconidia (Pascoe, 1990) cultures were routinely grown under NUV. In one case where cultures were incubated in stacks of three petri dishes, it was observed that the top culture always had more abundant mesoconidia than the lower ones, indicating that mesoconidia were also affected by light. This paper describes experiments on the effect of different light regimes on the abundance and morphology of mesoconidia and macroconidia.

The observation that mesoconidia appear to respond to light, and the fact that they are produced in the aerial mycelium, and are dry and easily dislodged from conidiophores, prompted speculation that they might be confined to above ground situations and dispersed by wind. Although it is logical to expect that production of dry conidia singly in the aerial mycelium represents an adaptation to air dispersal, there are few published reports of air dispersal of *Fusarium* which can be related directly to mesoconidia. An analysis of the extensive literature on trapping of fungal air spora (Lacey, 1981) shows that while many workers using isolation techniques (e.g. exposed plates) have isolated *Fusarium* spp., few cases of work involving trapping onto sticky slides or tapes have ever revealed *Fusarium*. This implies that the Fusaria isolated were not the result of easily recognised macroconidia but of other airborne propagules such as ascospores or micro- or mesoconidia, and that such propagules were not able to be identified during microscopic examination of spore trap slides or tapes. Although it may thus be suggested that Fusaria can be dispersed by airborne propagules other than macroconidia, none of the literature which mentions Fusaria isolated from air provides identification to species, so it is not possible to speculate further on the probable involvement of ascospores or micro- or mesoconidia.

Lukezic & Kaiser (1966), working with *F. roseum* "Gibbosum" (later identified as *F. semitectum*; Burgess, 1981) in banana plantations, demonstrated air dispersal of conidia produced on banana leaves. Their photograph of aerial conidiophores and conidia is clearly of mesoconidia. They showed that mesoconidia could be dispersed from banana stigmas and styles by wind speeds as low as 2.4 km/h, but that sporodochial macroconidia could not be dislodged by wind. Burgess (1981) discussed the production of "dry microconidia" by some populations of *F. equiseti* (Corda) Sacc. (*F. scirpi* Lamb. & Fautr. or *F. chenopodinum* (Thuem.) Sacc. as dealt with in this paper; Burgess, pers. comm.) from semi-arid areas of Australia and speculated that production of these conidia would facilitate wind-dispersal in a climate where rain seldom occurs.

In a brief experiment conducted at Rothamsted in 1982, with Dr. John Lacey, we attempted to demonstrate air dispersal of mesoconidia of *F. avenaceum* and *F. semitectum*. Pieces of agar culture (CLA or SNA) bearing abundant mesoconidia were placed in a wind tunnel, a vacuum pump was used to provide a constant air speed of 18 cm sec^{-1} and conidia were trapped by impaction on vaseline coated slides. In addition a jet was used to blow air at a range of speeds from 1-4 m sec^{-1}. We collected abundant mesoconidia of *F. semitectum* at 4 m sec^{-1} but only a very few mesoconidia of *F. avenaceum* at that speed. With suction alone (18 cm sec^{-1}) no conidia of either species were collected. Although only a brief experiment, conditions for liberation of mesoconidia were obviously not being adequately met.

During preparation of slides of mesoconidia and mesoconidiophores for morphological studies, it was noted that mesoconidia were dislodged from conidiophores as they were picked up by the needle. This indicated that mesoconidia could be liberated by vibration. Experiments were conducted on a range of mesoconidial and non-mesoconidial species to determine the ability of various propagules to be dislodged by vibration and dispersed by air.

MATERIALS and METHODS

1. Effect of osmotic water potential on mesoconidium production.

To test the effects of osmotic water potential on mesoconidium production, SNA and the water agar base of CLA were amended with 0, 4, 8, 16 and 32 g of KCl per litre of agar. Note that SNA normally has 0.5 g KCl as well as 1.0 g KH_2PO_4, 1.0 g KNO_3, 0.5 g $MgSO_4(7H_2O)$, a total of 3.0 g of Potassium and Magnesium salts plus 0.2 g glucose per litre of agar, so it already has a considerably lower osmotic water potential than water agar. Isolates of *F. avenaceum* (VPRI 12042, 12045, 12175), *F. chlamydosporum* (VPRI 12050, 12000), *F. chenopodinum* (VPRI 12063, 12065, 12067), *F. pallidoroseum* (VPRI 12078, 12075, 11965) and *F. sporotrichioides* (VPRI 12049) were selected for reliable mesoconidium production, and grown on CLA under NUV for production of macroconidia. Sporodochial macroconidia were streaked onto water agar and incubated for 24 h. Single germinated macroconidia were transferred to three 54 mm petridishes of the experimental media per isolate, and incubated under continuous NUV. Growth rates (radii) were measured at 2 and 4 days. Production of mesoconidia was assessed qualitatively by direct low power (10x) examination under the compound microscope at 2 and 5 days. Production of sporodochia on CLA was assessed qualitatively by examination under the dissecting microscope at 14 days.

2. Effect of light on mesoconidia and macroconidia.

Five light regimes were tested: continuous near ultraviolet light (CNUV); continuous cool white fluorescent light - three 20W cool white fluorescent tubes (CWF); intermittent NUV - 12 hr NUV/dark cycle (INUV); natural diffuse daylight in a glass-fronted incubator (partially supplemented by fluorescent room lighting during working hours); and continuous darkness (cultures enclosed in a metal box in the incubator). The NUV setup was as described by Booth (1971).

The incubator used for the daylight and dark regimes was run at 25°C. Temperature could not be controlled in the light cabinets but the NUV regime generated enough heat to run at around 24-28°C depending on ambient temperatures and the cool white fluorescent cabinet ran at about 3-4°C lower. Because only two fluorescent light cabinets were available, comparison of continuous and intermittent NUV and continuous CWF was carried out in three stages so that all combinations of the three regimes were tested against one another. Dark and daylight regimes were repeated with each combination of fluorescent light regimes.

One isolate of each species studied in the previous experiment, (*F. avenaceum*: VPRI 12175, *F. chlamydosporum*: VPRI 12052, *F. sporotrichioides*: VPRI 12049, *F. pallidoroseum*: VPRI 12078, *F. chenopodinum*: VPRI 12065) plus one isolate of *F. subglutinans* (VPRI 12816) was subcultured to CLA amended with 8 g/l KCl (CLA+K). Because *F. subglutinans* was discovered to produce mesoconidia late in this experiment, it was not able to be tested under cool white fluorescent light. Three replicates of each isolate were grown on CLA+K for 2 days at 25°C in a glass-fronted incubator and transferred to each light regime for 1 week before being assessed qualitatively for abundance of mesoconidia. After growth for another week they were assessed for production of sporodochia. Lengths of about 20 randomly selected mesoconidia were measured for each treatment.

3. Liberation and dispersal of mesoconidia.

The ability of mesoconidia to be liberated by vibration and dispersed by air currents was tested by subjecting petri-dish cultures of mesoconidial isolates to vibration at the mouth of a wind tunnel connected to a volumetric spore trap. Cultures of other species bearing only macroconidia or microconidia were compared in the same way. One isolate each of the following species was used: *F. avenaceum* (VPRI 12175), *F. chlamydosporum* (VPRI 12052), *F. sporotrichioides* (VPRI 12049), *F. pallidoroseum* (VPRI 12078), *F. chenopodinum* (VPRI 12065), *F. subglutinans* (VPRI 12816), and the following non-mesoconidial species, *F. moniliforme* (VPRI 12810), *F. oxysporum*, *F. equiseti*, *F. acuminatum* and *F. solani*.

All cultures were grown on CLA plus 8 gm KCl per litre of agar and incubated under continuous NUV. Mesoconidial species were grown for six days. Macroconidial and microconidial species were grown until abundant conidia of either type were present. Vibration was provided by dropping a 20g spherical lead weight from a height of 30 cm down a tube onto the bottom of an upturned petri-dish at the entrance to the wind tunnel. The wind tunnel and spore trapping device used was identical to Hirst and Stedman's (1962) quadruple ascospore liberation tunnels but only one of the four tunnels was used. Air was drawn through the tunnel at 10 litre/minute and conidia were collected on vaseline coated slides. The vacuum pump was run for 10 seconds before the petri-dish was inverted at the entrance to the tunnel and turned off 10 seconds after impact of the lead weight. Slides were examined under the compound microscope for presence of conidia.

RESULTS

1. Effect of osmotic water potential on mesoconidium production.

All isolates responded to the addition of KCl to CLA and SNA, with increased growth rates, mesoconidium production and sporodochium production (except in isolates where no sporodochia were produced). Growth rates after 4 days were higher on CLA than on SNA in all isolates, at all KCl concentrations, the difference being greatest in *F. pallidoroseum* isolates, and least in isolates of *F. avenaceum* and *F. sporotrichioides*. In all isolates growth rate was highest on CLA betwen 8 and 16 g l^{-1} KCl and on SNA between 4 and 8 g l^{-1} KCl. There was some inhibition of aerial mycelium in most isolates at 16 and 32 g l^{-1} KCl.

Production of mesoconidia was enhanced by addition of KCl to both media in all cases but optimum concentrations varied widely between isolates. In the most prolific producers of mesoconidia such as isolates of *F. chlamydosporum*, there was little observable difference in mesoconidium production between KCl concentrations. Mesoconidium production on CLA was usually greatest between 4 and 16 g l^{-1} KCl. Optimum KCl concentrations on SNA were generally lower than on CLA. When mesoconidium production at optimum KCl concentrations on CLA and SNA was compared directly for a given isolate, mesoconidium production on CLA was equal to or better than that on SNA.

Production of sporodochia was enhanced in most cases (except where no sporodochia were produced) by addition of KCl to CLA although there was great variability between isolates. There was usually some inhibition of sporodochium production at 32 g l^{-1} KCl. At high (16 and 32 g l^{-1}) concentrations, prolific KCl crystal production made observation of cultures difficult, and if cultures are to be dried for retention as herbarium specimens, 8 g l^{-1} KCl also results in sufficient crystal production to reduce the usefulness of dried cultures.

2. Effect of light on mesoconidia.

There were observable differences between light regimes in the abundance of mesoconidia and sporodochia on CLA. In most isolates, incubation in darkness was detrimental to production of both mesoconidia and sporodochia, while incubation under any of the three fluorescent light regimes resulted in production of abundant mesoconidia and sporodochia. The greatest difference in mesoconidium production between darkness and fluorescent light regimes occurred in *F. avenaceum* and *F. subglutinans*, and in these species, continuous light (NUV or CWF) was superior to intermittent (12 hour cycle) NUV. In *F. chlamydosporum* and *F. sporotrichioides*, differences in mesoconidium production were less apparent but followed the same pattern. In *F. pallidoroseum* the pattern is somewhat altered in that intermittent NUV produced more abundant mesoconidia than continuous NUV or CWF and these latter regimes were not greatly superior to the natural daylight cycle. In *F. chenopodinum* the situation is reversed with daylight and dark appearing to be superior to the fluorescent light treatments (this is explained in more detail below).

Sporodochium production was always most abundant in the fluorescent light treatments and least abundant in dark. In three species, *F. chlamydosporum*, *F. pallidoroseum* and *F. chenopodinum*, no sporodochia at all were produced in daylight or dark regimes. Of the fluorescent light regimes continuous NUV was most efficient in producing sporodochia.

Light regimes also differentially affected the uniformity of mesoconidia and mesoconidiophores. In *F. avenaceum*, *F. pallidoroseum*, *F. chlamydosporum* and *F. sporotrichioides*, mesoconidia appeared less uniform under direct low power examination of cultures grown under daylight or dark regimes than cultures grown under the three fluorescent light regimes. Conidiophores were less well developed, more sparsely branched and less uniform, and mesoconidia were less easily recognised. In *F. subglutinans* the ratio between mesoconidia and microconidia was affected by light regime. In darkness approximately 90% of conidia produced in the aerial mycelium were microconidia (small non-septate conidia in false heads) but under continuous NUV about 90% of conidia produced in the aerial mycelium were mesoconidia. In intermittent NUV, ratios were similar but conidiogenous cells were frequently seen to produce a single apparent mesoconidium followed by one or two microconidia from the same conidiogenous locus. In daylight there appeared to be complete intergradation between mesoconidia and microconidia, with the production of numerous conidia which could not adequately be identified as either conidial type.

In *F. chenopodinum* the situation is more complex. In this species mesoconidia were initially rated as more abundant under dark and daylight regimes than under the three fluorescent light regimes. However, a repeat of this experiment with *F. chenopodinum* showed that in the dark and daylight regimes conidia produced in the aerial mycelium were in fact mostly grouped in false heads of two or three conidia, rather than being produced singly. In the fluorescent light regimes conidia in the aerial mycelium were less abundant but almost all (especially in CNUV) were produced singly (i.e., true mesoconidia). The difficulty with *F. chenopodinum* is that the conidia produced in false heads in darkness, although strictly speaking not mesoconidia, are morphologically indistinguishable from true mesoconidia produced singly under fluorescent light regimes. Because of this morphological similarity to mesoconidia (1-3-septate, clavate) these conidia are difficult to classify as microconidia. Perhaps until further work is done on *F. chenopodinum* they are best regarded as aberrant mesoconidia.

Dimensions of mesoconidia were also affected by light regimes. In most species mesoconidia were longer in fluorescent light regimes than in daylight or dark, and within the fluorescent light regimes, CWF and continuous NUV produced longer mesoconidia than intermittent NUV. In *F. avenaceum* the difference in mean length between the superior light regime and the dark regime in the various experiments was 10-15 μm. Similar differences in mean length of mesoconidia also occurred in *F. pallidoroseum* and *F. subglutinans*. In *F. chenopodinum* and *F. chlamydosporum*, differences in mean length between the superior light regime and dark regime were of the order of 3-6 μm, but in *F. sporotrichioides* there were no consistent differences in mesoconidial length between light regimes.

3. Liberation and dispersal of mesoconidia.

Abundant mesoconidia were dislodged by vibration, transmitted through the wind tunnel and collected on vaseline-coated slides from isolates of *F. avenaceum*,

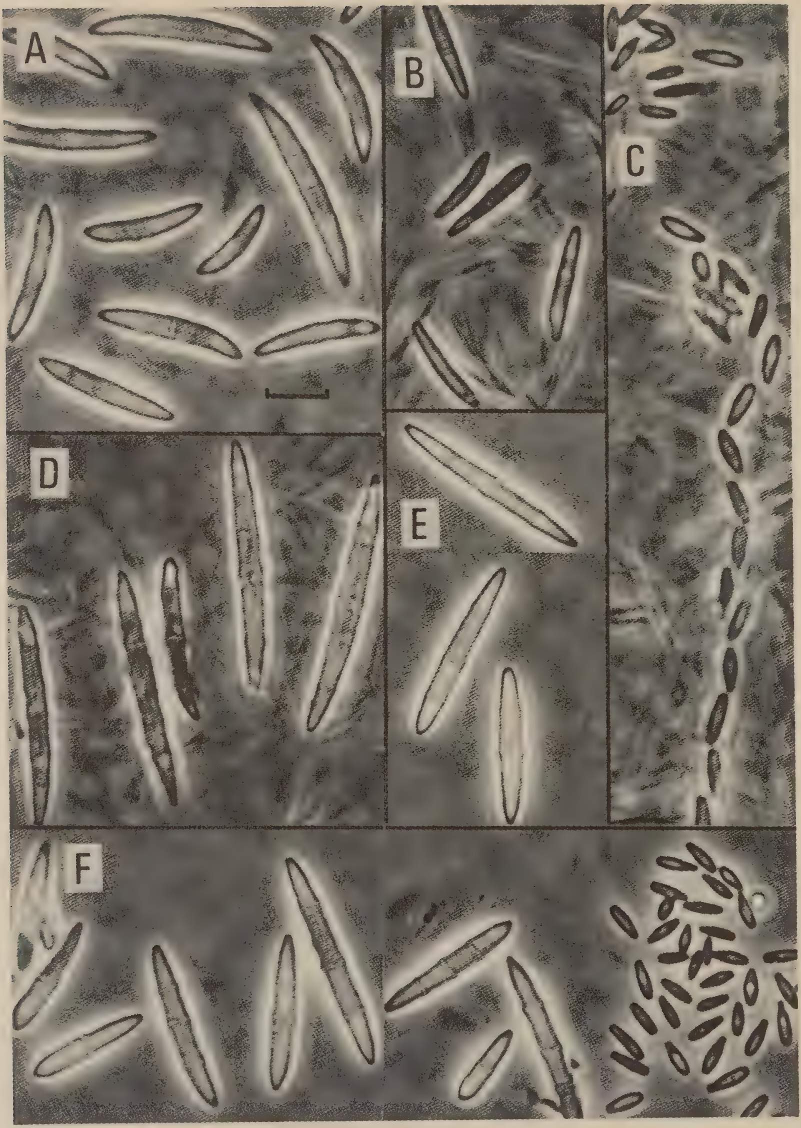

Fig. 1. Fusarium conidia liberated by vibration and trapped on vaseline-coated slides in a wind tunnel. A) *F. sporotrichioides* mesoconidia, B) *F. chlamydosporum* mesoconidia, C) *F. moniliforme* microconidia in chains and clumps, D) *F. pallidoroseum* mesoconidia, E) *F. avenaceum* mesoconidia, F) *F. subglutinans* mesoconidia and micro-conidia. Phase contrast microscopy, scale bar = 10μm.

F. sporotrichioides, *F. pallidoroseum*, *F. chlamydosporum* and *F. subglutinans* (Fig. 1). Only a few mesoconidia were collected from the isolate of *F. chenopodinum*. Small numbers of microconidia, aggregated in clumps, were collected from *F. subglutinans*. No conidia of any kind were collected from isolates of the non-mesoconidial species, *F. oxysporum*, *F. solani*, *F. acuminatum* and *F. equiseti*, but abundant microconidia were collected from the isolate of *F. moniliforme*. Trapped microconidia of *F. moniliforme* were seen on slides as chains and clumps (Fig. 1) indicating that both chains and false heads of microconidia of this species are capable of liberation by vibration.

DISCUSSION

Reduction of osmotic water potential by addition of KCL to CLA improved the production of mesoconidia by CLA to the extent that it was equal or superior to SNA in this respect, without reducing its superiority in growth rates and production of sporodochia. Although optimum KCl concentrations varied widely between isolates on CLA, 8 g l^{-1} appeared to be a reasonable average, as well as being the concentration found by Fisher et al. (1983) to be optimal for production of microconidial chains in section *Liseola*. CLA amended with 8 g l^{-1} KCl (abbreviated in this laboratory as CLA+K) should be further investigated for its potential as a routine growth medium for all *Fusaria*. If carnation leaf agar is not available, water agar amended with KCL and incubated under lights will produce good mesoconidia.

Use of artificial fluorescent light is essential for reliable production of mesoconidia in culture. Continuous fluorescent light supplemented by "black light" tubes giving a near-ultraviolet (NUV) component is recommended for production of mesoconidia and sporodochial macroconidia. The effect of light regimes on lengths of mesoconidia and on relative proportions of mesoconidia and microconidia in some species makes it important to fully document growing conditions whenever conidia of any kind are described or illustrated. The effect of light regimes on relative proportions of microconidia and mesoconidia of *F. subglutinans* should be borne in mind when working with this and similar species, especially since normal diffuse daylight results in production of numerous conidia which are difficult to classify as either mesoconidia or microconidia. *F. chenopodinum* has already been described as an atypical mesoconidial species, especially in its ability to produce more than one mesoconidium from each conidiogenous locus (Pascoe, 1990) and this tendency is exacerbated by dark or daylight regimes, and further emphasised by the dispersal experiments where the few mesoconidia dislodged by vibration appeared in pairs or small groups. Further work on light regimes and agar media is needed, however, to determine optimum conditions for production of microconidia and chlamydospores. Experience with *F. oxysporum* suggests that production of microconidia is inhibited by either NUV or weak media but optimum conditions for microconidia of *F. oxysporum* have yet to be determined.

The prediction, based on observations of habit and morphology, that mesoconidia could be liberated by vibration and dispersed by air currents was confirmed by experiment. Liberation by vibration and dispersal by air of *F. moniliforme* microconidia confirmed observations by Ooka and Kommedahl (1977) that this species was wind dispersed although these authors did not identify the propagules involved. Although these propagules were expected to be chains of microconidia as indicated by Hsieh et al. (1979), the detection of small numbers of microconidia of both *F. moniliforme* and *F. subglutinans* in clumps on spore trap slides indicates that liberation of apparently slimy false heads of microconidia is also common. It is noteworthy that the false heads of microconidia of these species are always considerably drier in appearance than those of *F. oxysporum*. It is probable that all species of section Liseola are provided with some means of dispersing conidia (whether mesoconidia or microconidia) by air. The failure of isolates of *F. oxysporum*, *F. solani*, *F. acuminatum* and *F. equiseti* to liberate microconidia or macroconidia in response to vibration and air currents indicates that the slimy masses of conidia of these species are only adapted to splash dispersal and not to air dispersal. The mesoconidial species and the chain-forming Liseola species can thus be regarded as having developed auxiliary spore forms to aid in air-dispersal of inoculum, almost to the exclusion of splash-dispersed macroconidia in the more successful cases such as *F. chlamydosporum* and *F. pallidoroseum*. Of course some species (such as *F. sporotrichioides*) have retained their versatility by producing macroconidia, microconidia and mesoconidia with equal reliability. *F. subglutinans*, which unlike the other important Liseola species does not produce microconidia in chains, appears to have compensated for this disadvantage in terms of air-dispersal, by producing mesoconidia.

These observations on liberation and dispersal of *Fusarium* mesoconidia and microconidia also help to explain some inconsistencies in the literature on fungal air spora. Burge et al. (1977) recovered substantial numbers of *Fusarium* cultures using an Andersen sampler, but could not find recognizable *Fusarium* macroconidia in deposits from a Burkard spore trap. Thus the propagules responsible for the cultures obtained could well have been mesoconidia or microconidia, and it is unfortunate that they did not identify the *Fusarium* species found, as this would have given an indication of the types of propagules involved. Pathak and Pady (1965) trapped large numbers of unidentified propagules which they termed "fusiform ascospores", but their comment that these spores resembled *Fusarium* macroconidia in shape (being fusiform, falcate and 2-8 celled, but lacking a foot cell), suggests that they may have been mesoconidia of a species such as *F. avenaceum*, *F. pallidoroseum* or *F. sporotrichioides*. Whether the diurnal periodicity shown by these spores is typical of mesoconidia of all species is not known, although Lukezic and Kaiser (1966) observed a diurnal periodicity of mesoconidia related to wind velocity rather than rainfall in a species later identified by Burgess (1981) as *F. semitectum* (*F. pallidoroseum*). Lukezic and Kaiser also found that mesoconidium liberation occurred at low wind speeds but was greatly increased when wind speeds were high enough to cause vibration of the affected tissue.

Mesoconidia appear to be highly specialized *Fusarium* conidia stimulated by weak nutrient environments, dry conditions and conditions of fairly intense light. It is hardly surprising therefore that mesoconidia have not been widely observed or described by mycologists who have traditionally worked with rich media such as potato dextrose agar (PDA) and who frequently incubated their cultures in conditions of natural diffuse daylight or in unlit incubators. It is perhaps an unfortunate coincidence that the species which most readily produce mesoconidia on PDA, *F. pallidoroseum* and *F. chlamydosporum*, produce mesoconidia which may easily be interpreted as macroconidia or microconidia respectively. The demonstration that mesoconidia are favoured by dry, well lit conditions and dispersed by air indicates that under natural conditions mesoconidia could be expected to occur on above ground parts of infected plant tissues, in dry environments or during drier seasons while macroconidia will predominate on above-ground parts exposed to rain splash, and microconidia (other than those of sect. *Liseola*) might occur more readily on sheltered or below-ground plant tissue. It is certainly not appropriate to regard all *Fusarium* species as exclusively splash-dispersed soil inhabiting organisms.

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NEW SPECIES AND COMBINATIONS IN VERMICULARIOPSIELLA (HYPHOMYCETES)

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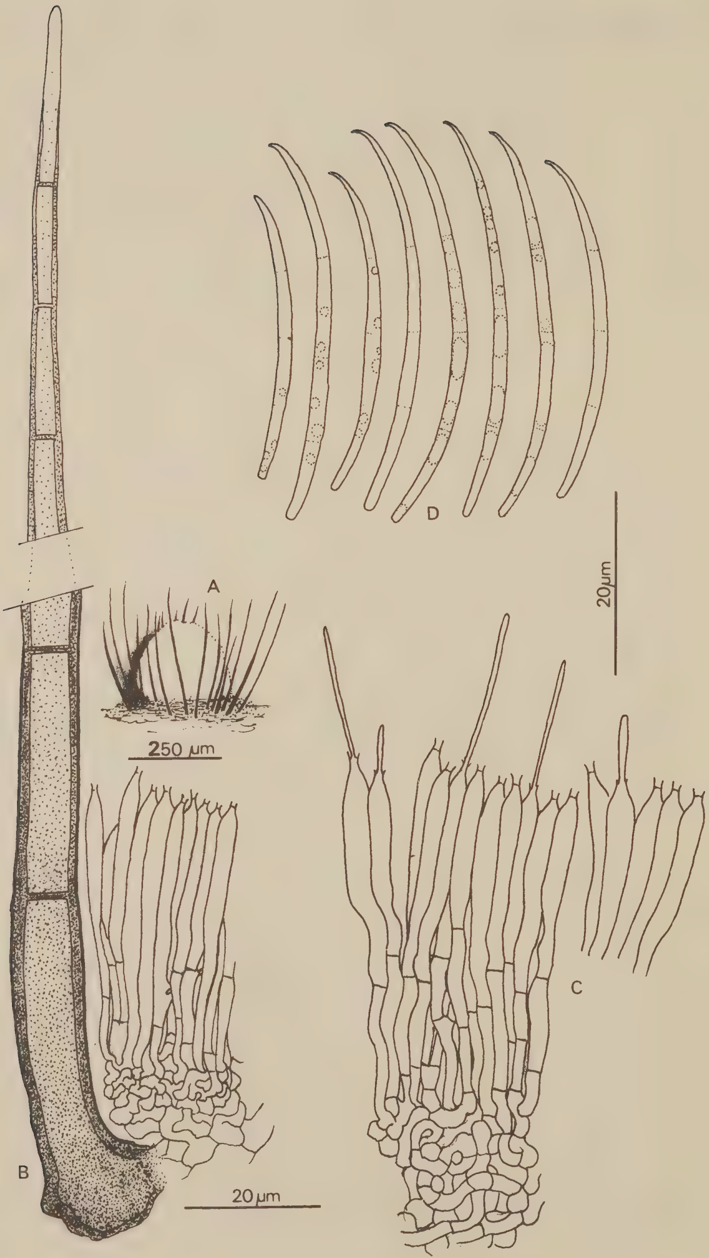
Vermiculariopsiella immersa (Desm.) Bender and two new species, **V. falcata** sp. nov. and **V. parvula** sp. nov. occurring on submerged decaying leaves and twigs in Malaysia are described and illustrated. **V. immersa** var. **ramosa** (Sutton) Nag Raj is elevated to species rank as **V. ramosa** (Sutton) comb. nov. Two other combinations are proposed, namely **V. cubensis** (Castañeda) comb. nov. (syn. **Oramasia hirsuta** Urries var. **cubensis** (Castañeda) and **V. cornuta** (V. Rao & de Hoog) comb. nov. (syn. **Gyrothrix cornuta** V. Rao & de Hoog). A key to the six known species is provided.

The genus **Vermiculariopsiella** was erected by Bender (1932) for **V. immersa** (Desm.) Bender, a setose, sporodochial hyphomycete with cylindrical, hyaline, non-septate conidia that are slightly curved and pointed at the apex and somewhat rounded at the base, produced in an agglutinated white mass on compact columns of cylindrical, obclavate, phialidic conidiogenous cells with flared collarettes. Nag Raj (1983) re-examined and traced the history of the taxon. He put **Oramasia** Urries (1956) in synonymy with **Vermiculariopsiella** and recognised two varieties, namely **V. immersa** (Desm.) Bender var. **immersa** and **V. immersa** var. **ramosa** (Sutton) Nag Raj, previously described by Sutton (1978) as **O. hirusta** Urries var. **ramosa.** Nag Raj & Kendrick (1986) also examined the lectotype of **Dinemasporium adeanum** Petrak and disposed it as a synonym of **V. immersa.**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This contribution reports on the occurrence of **V. immersa** and two undescribed hyphomycetes which are congeneric with **Vermiculariopsiella.** They were found in Malaysia on submerged decaying leaves and twigs collected from several freshwater streams subsequently incubated in moist chambers.

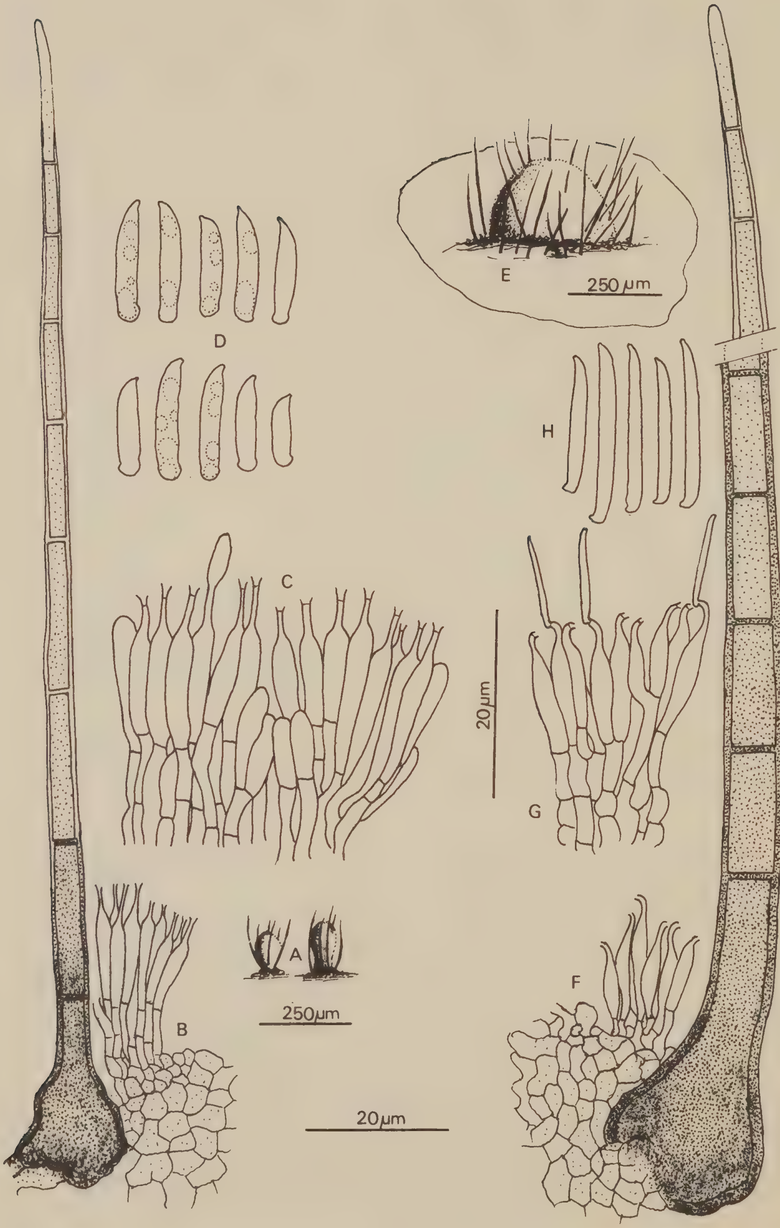
Vermiculariopsiella falcata sp. nov. Fig. 1

Coloniae effusae, inconspicuosae. Mycelium immersum ex hyphis ramosis, septatis, brunneis, 2 — 4 µm diam compositum. Conidiomata ex sporodochii, interspersa, solitaria, discreta, superficialia, setosa, usque ad 490 µm diam, agglutinata atra, cum conidia in massa composita. Stroma ex textura angularis constans, ad basim brunnea, superne pallidiora. Setae stromate, exorortae usque ad 38 per sporodochium natae, massum conidii, circumdatae fuscae, crassitunicatae, rigidae, erectae, rectae vel leniter curvatae, ad apicem attenuatae, laevigatae, 10 — 17 septatae, 217 — 480 µm longae, ad basim 6 – 13 µm latae et brunneae, 1 — 2 µm latae et pallidae ad apicem. Conidiophora compacta, parce ramosa, brevia, pallide brunnea, cylindrica. Cellulae conidiogenae cylindricae, monophialidicae, enteroblasticae, in conidiophoris incorporatae ad basim pallide brunneae, ad apicem hyalinae, laeves, 27 — 43 µm longae, 3 — 4 µm latae, cum collo brevi, colla infundibuliforme 1 — 1.5 µm lata praeditae. Conidia hyalina, laevia, 3-septata, guttulata, falcata, apicem acuminata, basim truncata vel rotundata, 36 — 47 µm longa, 1. 5 — 2 µm crassa.

Ex ramulum putridum in flumine immersi, Forest Research Institute, Kepong, Malaysia, A. Nawawi, 2 Oct. 1987, IMI 328845 holotypus.

Colonies effuse, inconspicuous. **Mycelium** immersed, composed of branched, septate brown hyphae, 2 — 4 µm diam. **Conidiomata** sporodochial, scattered, solitary, discrete, superficial, setose, up to 490 µm diam, black, with an overlying agglutinated white mass of conidia of up to 225 µm diam, turning yellowish brown with age. **Stroma** consisting of basal brown **textura angularis** from which the setae arise, becoming paler above and merging into the conidiogenous region. **Setae** up to 38

Fig. 1. **Vermiculariopsiella falcata.** A, habit sketch; B, part of a seta and basal stroma with conidiophore; C, conidiogenous cells with developing conidia; D, mature conidia.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per sporodochium surrounding the conidial mass, dark brown, thick-walled, rigid, erect, straight or slightly curved, tapered gradually to the apices, smooth, 10 — 17 septate, 217 — 480 µm long, inflated to 6 — 13 µm at the base, narrowing to 1 — 2 µm at the pointed to subobtuse, paler apices. **Conidiophores** compacted in the sporodochium, sparingly branched, short, pale brown, cylindrical. **Conidiogenous cells** arranged in compact columns, cylindrical, monophialidic, enteroblastic, integrated, pale olivaceous brown below, hyaline above, smooth, 27 — 43 µm long, 3 — 4 µm at the widest, narrowing to a short neck, aperture and channel narrow, collarette distinct, flared, 1 — 1.5 µm wide. **Conidia** hyaline, smooth, 3-septate, guttulate, falcate with the apex pointed and curved, base somewhat truncate to rounded, 36 — 47 µm long, 1.5 — 2 µm wide.

Other specimen examined: On submerged unidentified decaying twig, Ulu Gombak Field Study Centre, Malaysia, A.J. Kuthubutheen, Oct. 1988.

Vermiculariopsiella parvula sp. nov. Fig. 2, A-D

Coloniae effusae, inconspicuosae. Mycelium immersum ex hyphis ramosis, septatis, brunneis, 1.5 — 3 µm diam compositum. Conidiomata ex sporodochii, interspersa, solitaria, discreta, sessilia vel leniter elevata, setosa, usque ad 105 µm diam et 160 µm alta composita. Stroma ex textura globosa vel textura angularis constans, ad basim brunnea, superne pallidiora. Setae stromate, exorortae usque ad 5 — 15 per sporodochium natae, erectae, rectae vel leniter curvatae, crassitunicatae, laevigatae, 6 — 12 septatae, 118 — 313 µm longae, ad basim 13 — 20 µm latae et fuscae, 1.5 — 3 µm latae et pallidae ad apicem. Conidiophora parce ramosa, compacta, pallide brunnea vel subhyalina, usque ad 12 µm longa, 2 — 2.5 µm lata. Cellulae conidiogenae monophialidicae, subcylindricae vel lageniformes, hyalinae vel subhyalinae, tenuitunicatae, laeves, 14 — 21 µm

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Fig. 2. A - D, **Vermiculariopsiella parvula.** A, habit sketch; B, part of basal stroma with seta and conidiophores; C, conidiogenous cells with long straight apices and flared collarettes; D, mature conidia.

E - H, **Vermiculariopsiella immersa.** E, habit sketch; F, part of a seta and basal stroma with conidiophores; G, conidiogenous cells with recurved apices and flared collarettes; H, mature conidia.

longae 3 — 4 µm latae, cum collo recto et cylindrico 3 — 5 µm longo et colla infundibuliforme 0.5 — 1 µm lata praeditae. Conidia in massum alba, aliquando flava, agglutinata, hyalina, laevia, aseptata, guttulata, recta, cylindrica, ad apicem acuminata, ad basim rotundata vel obtusa, cum processa in eam partem afficionis, 8 — 13 µm longa 2 — 2.5 µm crassa.

Ex foliis angiospermis putrescentibus in flumine immersi, Brinchang, Cameron Highlands, Malaysia, A. Nawawi, 13 Nov. 1987, IMI 328844 holotypus.

Colonies effuse, inconspicuous. **Mycelium** immersed, composed of branched septate, brown hyphae, 1.5 — 3 µm diam. **Conidiomata** sporodochial, scattered, solitary, discrete, superficial, sessile or slightly raised, setose, up to 105 µm diam and 160 µm high. **Stroma** consisting of brown **textura globosa** to **textura angularis,** becoming paler above and merging into the conidiogenous region. **Setae** 5 — 15 per sporodochium, simple, erect, straight to slightly curved, mid to dark brown, lighter towards the subobtuse apex, 118 — 313 µm long, 5 — 9 µm wide below, tapering to 1.5 — 3 µm near the apex, thick-walled, smooth, 6 — 12 septate, expanded at the base to 13 — 20 µm. **Conidiophores** sparsely branched, densely packed in a palisade column, pale brown to subhyaline, up to 12 µm long, 2 — 2.5 µm wide. **Conidiogenous cells** monophialidic, subcylindrical to lageniform, hyaline to subhyaline, thin-walled, smooth, 14 — 21 µm long, 3 — 4 µm at the widest, narrowing abruptly to a narrow, straight, cylindrical neck 3 — 5 µm long, ending in a distinct flared collarette and channel 0.5 — 1 µm wide. **Conidia** produced in a white agglutinate mass, sometimes turning yellowish with age, hyaline, smooth, aseptate, guttulate, straight, cylindrical, apex slightly curved and pointed, base rounded to obtuse with a slight protuberance on one side noting the point of attachment, 8 — 13 µm long, 2 — 2.5 µm wide.

Other specimens examined: On submerged leaf petioles, Gunung Jerai, Kedah, Malaysia, A. Nawawi, 15 March 1988; on submerged leaves, Danum Valley, Sabah, A. Nawawi, 23 June 1989.

Vermiculariopsiella immersa (Desm.) Bender, **Mycologia 24:** 412 (1932) Fig. 2, E - H

Excipula immersa Desm., **Bull. Soc. Bot. Fr. 4:** 911 (1857).
Dinemasporium immersum (Desm.) Sacc., **Syll. fung. 10:** 439 (1892).

Vermiculariopsis immersa (Desm.) Hohn., **Ber. dtsch Bot. Ges. 36:** 317 (1918); **Mitt. Bot. Inst. Techn. Hochsch. Wien 6:** 32 (1929).
Oramasia hirsuta Urries, **An. Inst. bot. A. J. Cavanilles 14:** 168 (1956).
Dinemasporium adeanum Petrak, **Bot. Jahrb. Syst. Beiblatt 62:** 150 (1929), fide Nag Raj & Kendrick (1986).

Superficial **mycelium** inconspicuous. **Conidiomata** sporodochial, scattered, solitary, discrete, superficial, setose, 245 — 1105 µm diam, black with an overlying white mass of conidia, sporodochia often surrounded or demarcated by a dark thin line. **Stroma** consisting of a basal brown **textura angularis** from which the setae arise, becoming paler above and merging into the conidiogenous region. **Setae** numerous, 8 — 21 per sporodochium, dark brown, thick-walled, rigid, erect, straight to slightly curved, tapering gradually to the apices, smooth, 5 — 10 septate, 570 — 1325 µm long, inflated at the base, 8.5 — 12 µm wide at the 1st septum, narrowing to 4 — 6 µm at the subobtuse to acute apices. **Conidiophores** compacted in the sporodochium, sparingly branched, short, pale brown, cylindrical. **Conidiogenous** cells arranged in compact columns, monophialidic, subcylindrical to lageniform, hyaline to subhyaline, thin-walled, smooth, 11 — 15 µm long, 2 — 3 µm wide, narrowing to a recurved cylindrical neck and ending in a distinct flared collarette and channel 0.5 — 1 µm wide. **Conidia** produced in a white agglutinate mass, hyaline, smooth, normally aseptate, sparsely guttulate, straight, cylindrical, apex slightly curved and pointed, base obtuse to rounded with a pointed to subacute protuberance on one side indicating the point of attachment, 13 — 23 µm long, 1.5 — 2.5 µm wide.

Of the three species found in Malaysia, **V. immersa** appears to be the most common, occurring on decaying leaves and twigs. The sporodochia are variable in size but are generally large with many setae and are often demarcated by a thin black line, clearly visible when they occur on leaves. In most collections, the setae are rigid with subacute apices. In some collections, however, the setae tend to be thinner, lighter in colour and their tips drawn to a fine, hair-like structure. The conidia are within the range 13 — 27 µm long, 2 — 2.5 µm wide and sparsely guttulate. Conidia are generally non-septate, but in two collections some conidia were observed to develop 1 — 3 septa.

Specimens examined: On decaying leaves, Pusah Forest Reserve, N. Sembilan, A. Nawawi, April 1987; on decaying leaves, Lepar Forest Reserve, Pahang, A. J. Kuthubutheen, July 1986; on submerged decaying leaves, Bukit Rengit Pahang, A. Nawawi, 11 Nov. 1987; on submerged decaying twigs, Gunung Jerai, Kedah, A. Nawawi, 25 Feb. 1988; on submerged decaying leaves, Brunei, A. Nawawi, 23 Aug. 1988, IMI 328843.

Vermiculariopsiella ramosa (Sutton) comb. nov.

> **Oramasia hirsuta** Urries var. **ramosa** Sutton, **Mycologia 70:** 796 (1978).
> **Vermiculariopsiella immersa** (Desm.) Bender var. **ramosa** (Sutton) Nag Raj, **Mycotaxon 18:** 162 (1983).

The above combination is proposed based on re-examination and comparison of the type material of var. **ramosa** (IMI 215977c) on leaves of **Quercus virginiana** with several collections of **V. immersa** available in herb. IMI and also with those collected from Malaysia. The sporodochia of this species are generally smaller in diameter, each surrounded by abundant setae that are stout, erect and branched dichotomously once and rarely twice. The branching is very characteristic and is absent in all collections of **V. immersa** examined. The setae of **V. immersa** are generally longer and wider with blunt, acute to pointed apices. The differences between these two taxa, are in our opinion, sufficient to elevate var. **ramosa** to species level.

Vermiculariopsiella cubensis (Castañeda) comb. nov.

> **Oramasia hirsuta** Urries var. **cubensis** Castañeda, **Inst. Invs. Fund. Agric. Trop. "Alejandro de Humboldt" Cuba** p. 11 (1986).

Castañeda (1986) described this fungus from dead leaves in Cuba. It differs from **V. ramosa** in having setae, each ending in a cluster of 3 — 5 short, 2 — 3-celled primary branches that further rebranch to produce equally short secondary branches. The terminal cell of each secondary branch ends in a fine, hair-like appendage or trichome. In all other characters, this species is similar to **V. immersa** and **V. ramosa.**

Another taxon which is more satisfactorily accomodated in **Vermiculariopsiella** is **Gyrothrix cornuta** V. Rao & de Hoog (1986) described from rotting leaves in India. **Gyrothrix** (Corda) Corda as circumscribed by Ellis (1971, 1976) is characterized by conidiogenous cells that are polyblastic, discrete, solitary and percurrent. Conidia are dry, solitary, arranged in a ring just below the apex of the conidiogenous cells and often become detached in bundles. AN and BCS had the opportunity of examining several slides of **G. cornuta** (de H 5853) kindly lent by Dr de Hoog to herb. IMI. The setose stromatic conidiomata, phialidic conidium ontogeny, cylindrical phialides with flaring collarettes and unicellular, hyaline conidia with a short papillate protuberance at the base marking the point of detachment, are characteristic of **Vermiculariopsiella.** The following nomenclatural change is, therefore, proposed:

Vermiculariopsiella cornuta (V. Rao & de Hoog) comb. nov.

> **Gyrothrix cornuta** V. Rao & de Hoog, **Studies in Mycology (CBS) 18:** 68 (1986).

Key to species of **Vermiculariopsiella**

1. Setae unbranched 2
1. Setae branched 4

2. Conidia falcate, apex curved and pointed . . **V. falcata**
2. Conidia cylindrical, straight, apex acute, base rounded with a small sub-basal attachment scar 3

3. Conidia 14 — 25 µm long; conidiogenous cell apex recurved . . . . **V. immersa**
3. Conidia 8 — 13 µm long; conidiogenous cell apex narrow, long and straight . . . . . **V. parvula**

4. Setae mostly once dichotomously branched . **V. ramosa**
4. Setae thrice dichotomously branched . . . **V. cornuta**
4. Setae with short, primary and secondary branches; terminal cells with hair-like appendages . . . . **V. cubensis**

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A NEW SPECIES OF ALBATRELLUS (APHYLLOPHORALES: ALBATRELLACEAE) FROM MEXICO

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ABSTRACT

Albatrellus mexicanus is described as a new species from the Sierra Madre Occidental of the State of Chihuahua, Mexico. It is most similar to *A. pes-caprae*, from which it differs in having a smooth, glabrous pileus surface and ellipsoid basidiospores.

RESUMEN

Albatrellus mexicanus se describe como nueva especie de la Sierra Madre Occidental del Estado de Chihuahua, México. Es similar a *A. pes-caprae*, pero se diferencia por su píleo liso y glabro y sus basidiosporas elipsoidales.

The genus *Albatrellus* S.F. Gray is a group of approximately 20 species distributed primarily in the temperate regions of Europe and North America (Pouzar 1972; Gilbertson and Ryvarden 1986). Pouzar (1972) placed the genus in the subfamily Albatrelloideae Pouz. of the family Polyporaceae, while Nüss (1980) proposed the genus be segregated into the family Albatrellaceae (Pouz.) Nüss. Twelve species have been reported from the United States and Canada (Gilbertson and Ryvarden 1986), but only *A. cristatus* (Pers.:Fr.) Pouz. has previously been reported from Mexico. It has been reported from Chihuahua as well as from several other states (Pérez-Silva and Aguirre-Ocosta 1987). The group has received pharmacological attention in recent years since compounds extracted from several members of the genus have been shown to inhibit the growth of certain pathogenic microorganisms (Zechlin et al. 1981; Chaumont and Simeray 1982).

One of (JEL) recently collected an *Albatrellus* from the Sierra Madre Occidental of the State of Chihuahua, Mexico, which could not be assigned to any known species.

It is hereby described as a new taxon.

ALBATRELLUS MEXICANUS Lafer. & Gilbn., sp. nov.

Fructificatio terrestris, annua, stipitata, singularis vel confluens; stipes centralis ad excentricus; pileus siccus unicolor pallido-brunneus, glaber; superficie pororum alba, in stato sicca pallido-brunnea; pori angulati, 1.0-1.5 mm diam; systema hypharum contextum monomiticum; hyphae generatoriae fibulatae, tenuitunicatae, 4-10 mm diam; hyphae subskeletales in trama, aseptatae, leviter crassitunicatae, 2.5-5.0 µm diam; cystidia nulles; cystidiola rara, fusoidea basidia; clavata, 2-4 sterigmatibus, 36-46 x 9-11 µm; basidiosporae ellipsoideae, hyalinae, laeves, nonamyloidae, 8-10 x 5.5-6.5 µm.

Holotypus: J.E. Laferrière No. 1889, ad terram in sylvis mixtis, Nabogame, Municipio Temósachi, Chihuahua, Mexico, 30 Aug. 1988 (BPI, Isotypyes ARIZ, XAL).

Etymology: Of Mexico.

Basidiocarps terrestrial, annual, stipitate, single or confluent; stipe central to excentric, 3-5 cm long, 10-19 mm thick, light brown, glabrous; pilei single or confluent, circular to irregularly elliptical, convex, 5-10 cm in diam., glabrous; upper surface tan when fresh, drying uniformly pale brown, azonate, glabrous, smooth to rugose; pore surface white when fresh, drying light brown, the pores angular, 1.0-1.5 mm in diam.; dissepiments thin, entire, minutely fimbriate at first, becoming lacerate; tube layer concolorous with pore surface on dried specimens, drying brittle, 1.5-4.0 mm thick; context white at first, drying yellow, soft, fibrous, azonate, 3-11 mm thick.

Hyphal system of context monomitic; contextual generative hyphae thin-walled, hyaline, with frequent but often inconspicuous clamps, occasionally branched, 4-10 µm in diam.; gloeoplerous hyphae present in context, thin-walled, staining brightly in phloxine, with rare clamps, 5-11 µm in diam., often sinuous and with constrictions and swellings; trama with two types of hyphae; tramal generative hyphae similar to those of context, thin-walled, with inconspicuous clamps, 4-10 µm in diam.; skeletal-type hyphae also present in trama, firm to thick-walled, nonseptate, with occasional branching, 2.5-5.0 µm in diam; walls up to 1 mm thick; cystidia absent; rare fusoid cystidioles present, 28 x 10 µm; basidia clavate with a narrow base, 2-4 sterigmate, 36-46 x 9-11 µm, with a basal clamp; basidiospores ellipsoid, hyaline, smooth, negative in Melzer's reagent, 8-10 x 5.5-6.5 µm.

Substratum: on ground in mixed forest of *Cupressus arizonica* A. Gray, *Pinus engelmannii* Carr., and *Quercus* spp.

TYPE: Nabogame, Municipio Temósachi, Chihuahua, Mexico, 28°30′N, 108°30′W, elev. 1800 m, 30 Aug 1988, Laferrière

1889 (Holotype: BPI; isotypes: ARIZ, XAL).

Albatrellus pes-caprae (Pers.:Fr.) Pouz. is most similar to A. mexicanus, differing mainly in having a distinctly scaly or scrupose pilear surface. Spores of A. pes-caprae are more distinctly lachrymate and broader than those of A. mexicanus. Firm to thick-walled hyphae occur in the trama and context of both species.

Albatrellus cristatus basidiocarps differ from those of A. mexicanus in their yellowish-green to yellowish-brown coloration of the pileus and also in having much smaller (5-7 x 4-5 µm), slightly amyloid basidiospores. Dried specimens of A. cristatus also develop distinct reddish coloration of the pore surface and tube layer.

Albatrellus mexicanus may be distinguished from A. pes-caprae by the following key:

Pileus glabrous; basidia 2-4-sterigmate; basidiospores ellipsoid .... A. mexicanus

Pileus with scales 1-2 mm wide composed of erect, loose clumps of hyphae; basidia 4-sterigmate; basidiospores lachrymate .... A. pes-caprae

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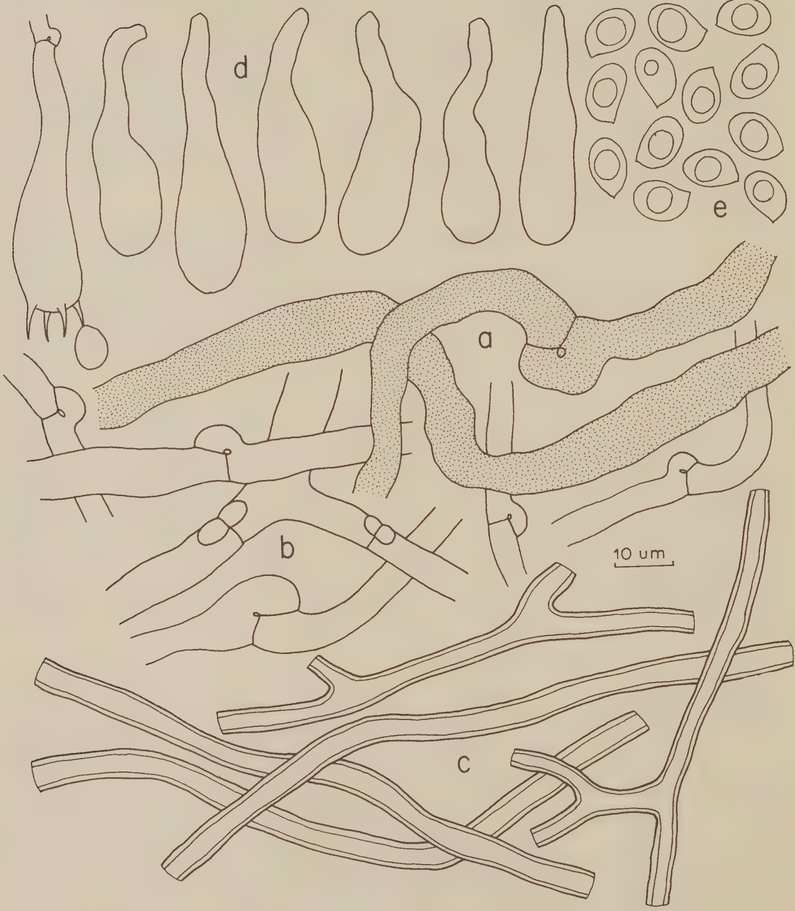

Figure 1: *Albatrellus mexicanus* (Laferrière 1889, type). a, gloeoplerous hyphae from context; b, contextual generative hyphae; c, firm-walled, nonseptate hyphae from trama; d, basidia; e, basidiospores.

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CALVATIA PACHYDERMA (Peck)Morgan IS GASTROPILA FRAGILIS (Lév.)Homrich & Wright

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A puff-ball sent to me recently by Lic. María Paz Martin from Catalonia, Spain, which she had previously recorded as *Calvatia pachyderma* (Peck) Morgan (Paz Martin, 1988), and which I determined as *Gastropila fragilis* (Lév. Homrich & Wright, revived the issue concerning the identity of the former, which was well described by Peck (1882, as *Lycoperdon pachydermum*; Saccardo, 1888) from Arizona, USA. When we dealt with the genus *Gastropila* (Homrich & Wright, 1973) for Southern South America, we did not concern ourselves with this problem, but later, while studying collections of *Calvatia* from the same area, we came accross the review of this genus for Noth America by Zeller & Smith (1964), where there is a good description of *C. pachyderma* (Peck) Morgan. In this paper the authors erected a Stirps *Pachyderma*, whose description is only given as part of the key to the Stirpes of *Calvatia*, namely: "Gleba reddish brown, umber brown, olive brown to ochraceous... peridial wall hard and *Scleroderma*-like at maturity". They included in this Stirps *C. fumosa* var. *fumosa*, *C. hesperia*, *C. subcretacea*, *C. pachyderma* and *C. fumosa* var. *idahoensis*.

I have now been able to study the holotype of *Lycoperdon pachydermum* Peck, thanks to the courtesy of Dr. John H. Haines (**NYS**) - to whom I wish to extend my thanks- and I have only found slight variations from the type and other collections of *Gastropila fragilis* (Lév.) Homrich & Wright which, being a prior name, becomes the valid epithet for *C. pachyderma*.

The holotype is practically in crumbles - a characteristic it shares with *G. fragilis* - and the gleba has disappeared, but its remnants coincide in their features with those we have described and illustrated for *G. fragilis* in our 1973 paper. The spores are 4.16-4.68 x 3.12-3.67 µm, with a small pedicel which in a few instances may reach up to 4 µm long (immature?). The capillitium, much disintegrated into short portions, is 2.6-5.7 µm diam. with thickened and pitted walls. The spores are thus somewhat smaller than the measurements given both by Zeller & Smith (*op. cit.*), Homrich and Wright (*op. cit.*) and Paz Marin (*op. cit.*), whereas the capillitium threads coincide with the measurements we recorded, and those of the latter authors.

Coker & Couch (1928) referred to *C. pachyderma* in a foot-note on p. 60 stating that "the peridium is smooth or with thin adherent patches, and there are not separable layers, although the entire peridium is apt to be scissile like short-cake; spores (in plant from the type locality, collected by Pringle and determined by Peck), oval to elliptic, very finely warted under high power (2160 x), 3.5-4 x 4.2-6 µm, with a mucro or short pedicel; capillitium threads fragmented, strongly olivaceous yellow under the microscope, irregular in thickness, rather frequently branched, pitted, up to 11 µm thick in swollen places; mature gleba olivaceous". The statement of both Coker & Couch and Zeller & Smith that some spores are "finely warted" is baffling, since we were unable to confirm it in our study of the holotype, all of them being smooth under high power.

A thorough study of all the species in Zeller & Smith's Stirps *Pachyderma* would be interesting, since it might prove to be identical with the generic segregate we are calling *Gastropila*. A few remarks of interest recorded by both Coker & Couch and Zeller & Smith for *C. pachyderma* are illustrative of features of *G. fragilis* and deviate from those exhibited by other species of *Calvatia*, namely: smooth peridium with no separable layers; the peridium being apt to become scissile like short-cake; the smooth spores with a mucro or short pedicel; the nature of the capillitium threads, and the thick, empty peridial sheaths without any indication of a sterile base, reminding of *Mycenastrum corium*.

Recently, H. Kreisel has examined the holotype of *L. pachydermum* and annotated on the label "*Langermannia pachyderma* (Peck)Kreisel". If the present species proves to be congeneric with Langermannia gigantea (Batsch:Pers.) Rostkov, then Gastropila would become a synonym of this genus. This seems unlikely, in view of the nature of the peridium in Langermannia as well as of its capillitium. There is certainly nothing "Scleroderma-like" in this genus.

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ESCOVOPSIS, A NEW GENUS FROM LEAF CUTTING ANT NESTS TO REPLACE **PHIALOCLADUS** nomem invalidum.

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An interesting genus in which sporophores are covered with jar shaped sporogenous cells with elongate necks is described. The fungus was isolated from leaf cutting ant nests. This genus was previously invalidly published as Phialocladus and a discussion on why the name was not validated is given.

Many different fungi are associated with leaf cutting ants. Most of these are utilized by the ants to provide nourishment for the ant colony and have been classified in the Basidiomycotina. During biosociological studies of Atta spp. colonies maintained **in vitro** (Della Lucia, Vilela and Moreira, 1987), a unique fungus was observed colonizing the surface of the organic litter - basidiomycete mass.

The fungus belongs to a monotypic genus of imperfect fungi published by Kreisel (1972) as Phialocladus, based on P. zsoltii. Problems arise with this classification as no type specimen of P. zsoltii was indicated when the genus was published which makes the name invalid according to article 37 of the International code of Botanical Nomenclature {hereafter referred to as the code} (Hawksworth, 1974). To validate the genus, it becomes necessary only to designate the type species. However, in our work with this fungus, macroconidia have not been found as stated in the original diagnosis. This would necessitate a change of the diagnostic characteristics of the genus so as to include only the extremely characteristic sporophores. This alteration does not warrant a change in name according to article 51 of the code (Hawksworth, 1974).

Another problem that arises with the original description of the fungus is in the use of the word phialide for the sporogenous cells. If a phialide is to be considered "a type of conidiogenous cell that produces conidia in a basipetal fashion" (Alexopoulos and Mims, 1979, p 596) then this fungus might be considered to produce phialides. However, if a phialide is "a conidiogenous cell which produces, from a **fixed** conidiogenous locus, a basipetal succession of **enteroblastic** conidia whose walls arise de novo" (Kendrick, 1971, p 259), then this fungus does not produce phialides. A conidium produced in a phialide as explained by Subraminian (1971) is at least partially internal during its formation with a junction between conidium and phialide visible. Due to the extremely small diameter of the apex of the sporogenous cell, it is difficult to visualize that the spore could be internal at any point during its formation. Also, with scanning electron microscopy, no visible division on the surface of the sporogenous cell were encountered (Fig. 1) which leads us to believe that the fungus is holoblastic.

The growth habit of this fungus is most intriguing. The hyphae are rather thick and branch, forming septa only much later. Septa are found only at the base of spore producing cells and in old mycelium. With this fungus, old mycelium can be considered as any that has more than 4 days of age. This is most troublesome if this fungus is to be considered a Hyphomycete with an Ascomycete or Basidiomycete teliomorph, since these fungi have somatic hyphae which is normally of a significantly smaller diameter than that of the sporophore.

Based on these arguments, it is troublesome to validate the name Phialocladus since it would be understood from the root of the name that sporogenesis is phialidic.

Escovopsis gen.nov.

= Phialocladus Kreisel, Z. Allg. Microbiol. 12:649.
Sporophori incolor, cylindirca supersternere cum cellular sporogenae discreta sphaerae basilare cum colli tenuie et attenuata. Spora basipetalitre catenata.

Brazil, Minas Gerais, Viçosa, em colonae formicae, T. M. Della Lucia. Herbario, UFV holotypus.
Etym. Escova - Portuguese for brush, -opsis Greek for like (brush like due to the bottle-brush appearance of the sporophore.

Sporophore light brown, cylindrical, covered with discrete sporogenous cells which are globose at the base and with a thin tapering neck. Spores basipetally catenate.

Escovopsis weberii sp.nov. (Fig. 1).

= Phialocladus zsoltii Kreisel, Z. Allg. Microbiol. 12:649. (nomen invalidum: type not designated).
Hyphae incolor, laeves, ramosae, juxta anguli dextatra, usque ad 14 um crasse. Sporophori incolor, terminale, sessile, cylindrica em apicis rotundata, supersternere cum cellulae sporogena sphaerae, 3-4.5 um dia., cum culli tenuie et attenuata (usque 4.5 um). Spora globosa ad ovata, incolor, laevia, basipetaliter catenata, 2.2-3.3 x 2-3 um.
Brazil, Minas Gerais, Viçosa, em colonae formicae, T. M. Della Lucia. Herbario, UFV holotypus. March 25, 1987 (ATCC 64542 ex holotypus).
Etym. for N. A. Weber, American entomologist who found this fungus in the 1960's.

Hyphae hyaline, light brown with age, smooth, with right angle branching, thin walled but thick, up to 14 um wide. Sporophores terminal, sessile, hyaline, light brown with age, elongate cylindrical with a rounded apex, separated by a thick septum from the hyphae, 43-58 x 11.5-14 um, covered

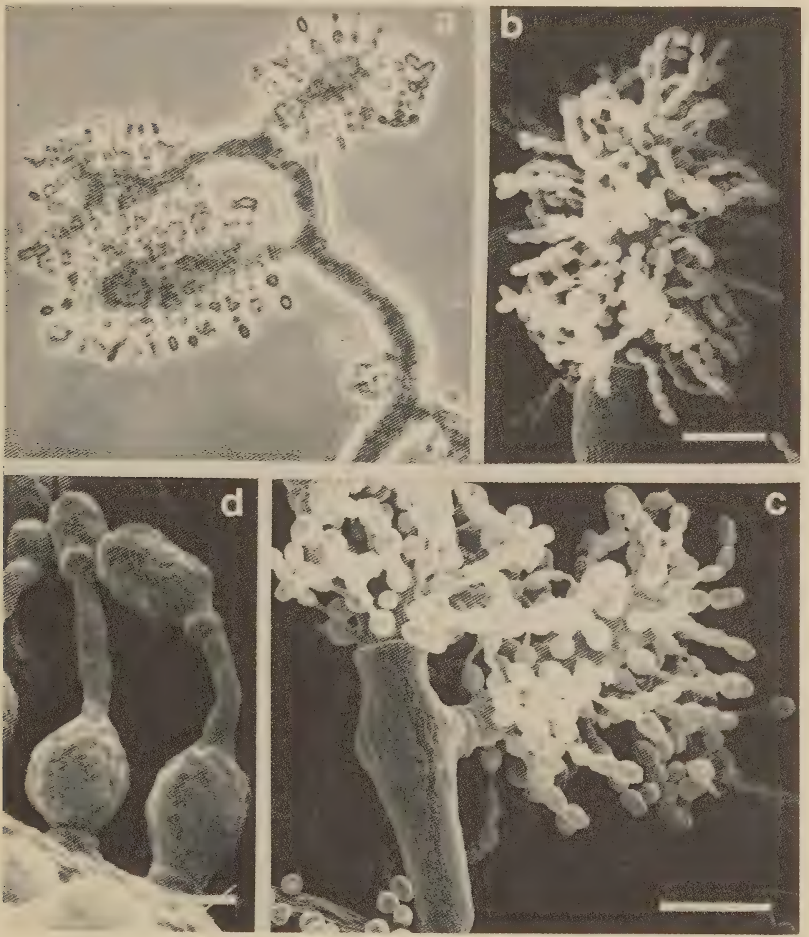


Fig. 1. Escovopsis weberii. a) phase contrast photomicrograph of sporophores and sporogenous cells (x425); b,c,d) scanning electron micrographs of sporophores (b and c) and sporogenous cells (d). Note the catenulate nature of the spores and the basipetal formation. Bar = 10 um on b and c and 1 um on d.

with discrete sporogenous cells. Sporogenic cells are globose basally (3-4.5 um dia.) with a thin tapering neck (up to 4.5 um long from which the spores are formed, and appear to be separated from the sporophore by septa. Spores are globose to ovoid, hyaline, smooth, basipetalously catenate, 2.2-3.3 x 2-3 um.

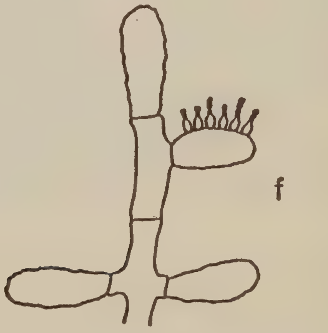
The species originally assigned to Phialocladus is P. zsoltii which presents conidiophores of up to 50 um in length and 8-13 um in width. The conidiogenous cells were of a diameter of 3.8-5 um and up to 6 um in length. These characteristics do not differ considerably from those of our isolate. Therefore, we believe these fungi to be cospecific.

Sporogenisis is difficult to positively ascertain. Under light and scanning microscopy, the spores do not have flattened areas of contact, nor are rings apparent on the tops of the sporogenous cells.

In culture, growth is slow and white at first. Mycelium is aerial and later becomes yellowish brown and then reddish brown with age. Attempts to preserve the culture by lyophilization and constant mass transfer have been unsuccessful.

Several genera of imperfect fungi possess general similarities to Escovopsis but all differ by one or more major characteristics (Barnett and Hunter, 1987; Barron, 1968; Carmichael et alii, 1980). Amblyosporium differs due to the ontogeny of conidia which are thallic with scars on the conidia (Pirozynski, 1969). Olpitrichum and Acladium are dark and hyaline, respectively, but produce large spores on denticles which lack a basal bulb (Barron, 1968; Carmichael, et alii, 1980). Ostracoderma produces conidiogenous cells which radiate from a central point and lack the bulbous conidiogenous cells.This fungus is readily recognized by the rather large conidiophores which are covered by jar shaped conidiogenous cells with a long beak.

Escovopsis weberii is associated with leaf cutting ant nests in decline. This has been established through our own observation and collaborates the observations of Weber (1965) whom provides what we believe to be the first illustration of this fungus (Fig. 2).



SCIENCE, VOL. 153

Fig. 2. Sporophore and sporogenous cells as depicted by Weber (1966). [Reprinted with permission of the American Association for the Advancement of Science.]

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OBSERVATIONS ON POORLY KNOWN MANGROVE FUNGI AND A NOMENCLATURAL CORRECTION.

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ABSTRACT

Thirty-eight marine fungi growing on mangrove material (largely wood) are reported from the Indian Ocean and South East Asia. The data confirms that mangrove fungi are widely distributed in the tropics.

Cucullospora Hyde *et* Jones a *nomen illegitimum* is transferred to *Cucullosporella* Hyde *et* Jones, nom. nov.

THE MANGROVE FUNGI

Our studies of mangrove fungi from Brunei, Malaysia, Philippines, Seychelles, Singapore, Sumatra and Thailand (Hyde, 1988a,b; Hyde and Jones, 1988; Jones and Kuthubutheen, 1989; Jones, Uyenco and Follosco, 1988) indicate that many recently described species are widely distributed in the tropics. In Table 1 we list a number of mangrove fungi described since 1980 with their current distribution in the Indian Ocean and South East Asia. Records for Bali and Mauritius are new. Samples of intertidal mangrove were collected from Poste LaFayette, Mauritius (January, 1988) and Kuta mangrove, Bali (February 1988) and examined for marine fungi. Voucher slides of the fungi collected are held in K.D. Hyde's herbarium.

DISCUSSION

Thirty-six tropical marine fungi described since 1980 are listed in Table 1. Of these, 5 are known only from their original location (*Aigialus rhizophorae*, *Bathyascus avicennae*, *Ophiodeira monosemeia*, *Pleospora avicenniae*, *Cirrenalia basiminuta*). The species most frequently reported are *Halosarpheia ratnagiriensis* (from 9 out of 10 localities), *H. marina* (9:10), *Hypoxylon oceanicum* (9:10) and *Massarina velataspora* (8:10). All have been reported as regular colonisers of mangrove wood (Hyde and Jones, 1988; Jones, Uyenco and Follosco, 1988; Jones and Tan, 1987; Tan, Leong and Jones, 1989; Leong, Tan and Jones, 1989) with the exception of *H. ratnagiriensis*.

TABLE I. MANGROVE FUNGI DESCRIBED SINCE 1980 AND COLLECTED AT VARIOUS LOCATIONS IN THE INDIAN OCEAN AND SOUTH EAST ASIA.

	Bali	Brunei	India	N. Sumatra	Malaysia *1.	Mauritius	Philippines	Seychelles *2.	Singapore	Thailand	
ASCOMYCOTINA											
Acrocordiopsis patilii Borse *et* Hyde	–	+	+	–	–	–	+	–	–	–	3
Aigialus grandis Kohlm. *et* Schatz	+	+	+	+	+	–	–	+	+	–	7
A. mangrovis Borse	–	+	+	–	–	–	–	+	+	–	4
A. parvus Schatz *et* Kohlm.	–	+	+	+	+	–	–	–	+	–	5
A. rhizophorae Borse	–	–	+	–	–	–	–	–	–	–	1
Aniptodera mangrovei Hyde	–	+	–	+	+	–	+	+	–	–	5
Ascocratera manglicola Kohlm.	–	+	–	–	–	–	–	–	–	–	1
Bathyascus avicenniae Kohlm.	–	–	–	–	–	–	–	–	–	–	0
B. grandisporus Hyde	–	+	–	–	–	–	–	+	–	–	2
Belizeana tuberculata Kohlm. *et* Volkm.	–	+	–	–	+	–	–	+	–	–	3
Biatriospora marina Hyde *et* Borse	–	+	+	–	+	–	–	+	–	–	4
Caryosporella rhizophorae Kohlm.	–	+	–	–	+	+	–	+	–	–	4
Cucullosporella mangrovei (Hyde *et* Jones) Hyde *et* Jones	–	+	–	–	+	–	–	+	–	–	3
Didymella avicenniae Patil *et* Borse	–	+	+	+	–	–	–	–	–	–	3
Halosarpheia abonnis Kohlm.	+	+	+	–	+	–	–	+	–	–	5
H. cincinnatula Shearer *et* Crane	–	–	–	–	–	–	–	+	+	–	2
H. lotica Shearer	–	–	–	–	+	–	–	–	+	–	2
H. marina (Cribb *et* Cribb) Kohlm.	+	+	+	+	+	+	+	+	+	–	9
H. ratnagiriensis Patil *et* Borse	+	+	+	+	+	–	+	+	+	+	9
H. retorquens Shearer *et* Crane	–	–	+	–	–	–	+	–	+	–	3
H. viscosa (Schmidt) Shearer *et* Crane	–	+	–	+	–	–	+	+	–	–	4
Hypoxylon oceanicum Schatz	+	+	+	+	+	+	+	+	+	–	9
Lanspora coronata Hyde *et* Jones	–	–	–	–	+	+	–	–	–	–	2
Lignincola tropica Kohlm.	–	+	–	–	–	–	–	–	+	–	2
Lophiostoma mangrovis Kohlm. *et* Vittal	–	–	+	–	+	+	–	–	–	–	3
Marinosphaera mangrovei Hyde	+	+	–	+	–	+	–	–	–	+	5
Massarina thalassiae Kohlm. *et* Volkm.-Kohlm.	–	+	+	–	+	+	–	–	–	–	4
M. velataspora Hyde *et* Borse	+	+	+	+	+	+	+	+	–	–	8

Nais glitra Crane *et* Shearer	-	-	-	+	+	-	-	-	+	-	3
Ophiodeira monosemeia Kohlm. *et* Volkm.-Kohlm.	-	-	-	-	-	-	-	-	-	-	0
Passeriniella savoryellopsis Hyde *et* Mouzouras	-	+	-	-	-	-	-	+	+	-	3
Pleospora avicenniae Borse	-	-	+	-	-	-	-	-	-	-	1
Rhizophila marina Hyde *et* Jones	+	+	-	+	-	-	-	+	-	+	5
Swampomyces armeniacus Kohlm. *et* Volkm.	-	-	-	-	+	-	-	+	-	-	2
Thalassogena sphaerica Kohlm. *et* Volkm.-Kohlm.	-	+	-	-	-	-	-	-	-	-	1
Trematosphaeria lignatilis Kohlm.	-	+	-	+	+	-	-	+	-	-	4
T. striataspora Hyde	-	+	-	+	-	-	-	-	-	-	2
DEUTEROMYCOTINA											
Cirrenalia basiminuta Raghu-Kumar	-	-	+	-	-	-	-	-	-	-	1
Total 38	8	26	17	14	19	8	8	19	12	3	

*1. Data from Jones and Kuthubutheen (1989).
*2. Data from Leong, Tan and Jones (in press); and Jones (unpublished).

Hypoxylon oceanicum has been referred to under *Rosellinia* sp. by many workers (Hyde, 1988; Hyde and Jones, 1988; Jones, Uyenco and Follosco, 1988). We consider this fungus is misplaced in *Hypoxylon* and a new genus is to be described to accommodate it (Whalley, personal communication).

The data presented suggest that these fungi are widely distributed in the tropics (Kohlmeyer, 1986; Kohlmeyer and Volkmann-Kohlmeyer, 1987; Borse, 1987a,b, 1988), while some are cosmopolitan (e.g. *Halosarpheia marina*, *H. cincinnatula* and *H. viscosa*). Further studies are required of a number of species, only recently described, before their true geographical distribution is known (e.g. *Cirrenalia basiminuta*, *Ascocratera manglicola*, *Ophiodeira monosemeia*) (Kohlmeyer and Volkmann-Kohlmeyer, 1988; Raghukumar, Zainal and Jones, 1988).

A CORRECTION

In a recent publication (Hyde and Jones, 1986) *Cucullospora* was proposed as a new generic name. However, the name is a *nomen illegitimum* under Article 64.2 and 64.3, Ex. 5 as it is a homonym of *Cucullispora* B.W. Scheuring, 1970 (Fossil Sporae Dispersae) (Anon, 1987).

The name Cucullosporella is therefore proposed in its place.

CUCULLOSPORELLA Hyde et Jones, nom. nov.

Typus: Cucullosporella mangrovei (Hyde et Jones) Hyde et Jones.

Syn. Cucullospora Hyde et Jones.

Botanica Marina 29: 491: 1986 (non Cucullispora Scheuring).

CUCULLOSPORELLA MANGROVEI (Hyde et Jones) Hyde et Jones comb. nov.

Bas. Cucullospora mangrovei Hyde et Jones.

Botanica Marina 29: 491: 1986.

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MYCOTAXON

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STUDIES IN LEPTOSPHAERIA. TRANSFER OF L. MASSARIOIDES TO MASSARIOSPHAERIA

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Leptosphaeria massarioides Saccardo & Spegazzini was described from the decaying stems of *Heracleum sphondylium* L. (Umbelliferae) in Italy in 1878 (Saccardo, 1878). The species is known only from its type locality and was characterized as having immersed perithecia with acute papillae and dark, 7-septate phragmospores. The fungus was mentioned by Berlese (1893), who suggested that it might be better placed in *Lophiostoma* Ces. & De Not. because of the presence of a laterally compressed ostiole. However, transfer to *Lophiostoma* was not made. The presence of a slot-like ostiole and dark phragmospores might have warranted its inclusion within *Lophiostoma* in the sense of Saccardo (1878, 1883) but recent revision of the genus (Holm & Holm, 1988) has resulted in placement of some species with those characteristics in what is referred to as related "normal" genera. Holm & Holm (1988) transfer a few such 'lophiostomataceous' fungi into other genera, including *Massariosphaeria* (Mueller) Crivelli.

Mueller (1950) erected *Massariosphaeria* as a section of *Leptosphaeria* Ces. & De Not. for those fungi having relatively large, thick-walled ascospores surrounded by a prominent mucilaginous sheath and, in many instances, having a fruit body with a thickened apex composed of thick-walled cells. Crivelli (1983) raised *Massariosphaeria* to generic rank and included dictyosporous species. He emphasized cultural characteristics, such as purple-red pigments and type of anamorph produced, along with the spore and ascocarp characters noted by Mueller. Crivelli also mentioned that, within the genus, the ostiole can vary from being round to slot-like "(as in the Lophiostomataceae)". Leuchtmann (1984) treated the phragmosporous members of the genus in the same sense as Crivelli.

We do not feel that transfer of *Leptosphaeria massarioides* to *Lophiostoma* should be made based on the lophiostomataceous criteria of slot-like ostiole and flattened neck, but rather that *L. massarioides* would best be placed in the genus *Massariosphaeria* because of the characteristic thickening of the neck cells, spore morphology and possession of a prominent ascospore sheath.

Massariosphaeria massarioides (Saccardo & Spegazzini) Huhndorf, Crane & Shearer, comb. nov. Figs. 1-9.

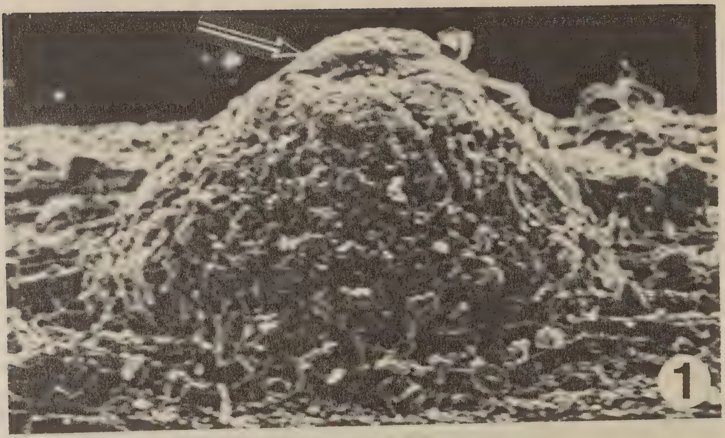
≡ *Leptosphaeria massarioides* Saccardo & Spegazzini, Michelia 1: 394, 1878. (Basionym).

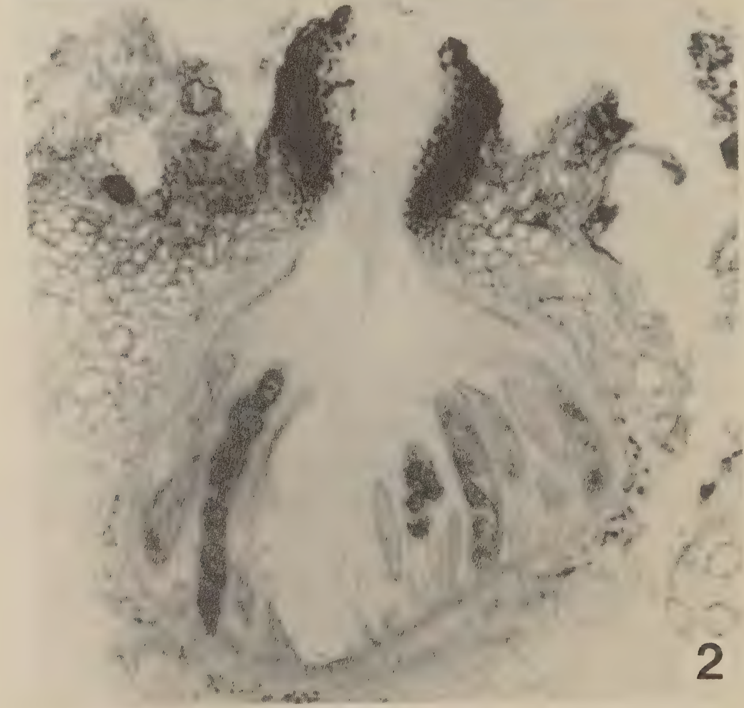
≡ *Heptameria (Leptosphaeria) massarioides* (Saccardo & Spegazzini) Cooke, Grevillea 18: 31, 1889.

Holotype: ITALY, in caulibus putrescentibus superficie denigratis *Heracleum sphondylium* a Conegliano, Oct. 1877. (PAD !)

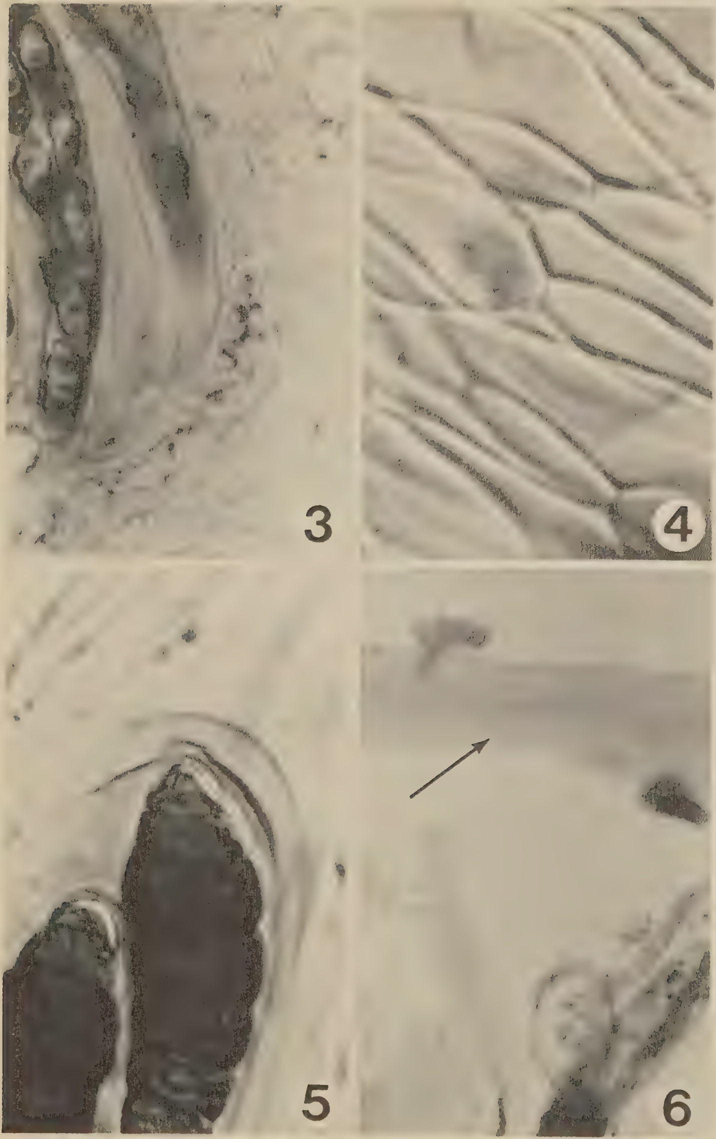
Ascocarps scattered, sparse, immersed-erumpent, papillate, glabrous, globose, 270-300 µm. Papilla short, erumpent, elongate-conical, 75-115 µm high, 75-100 µm wide, composed of 5-7 layers of prominent, dark-brown, scleroplectenchymatous cells surrounding a 40-65 µm wide, slot-like ostiole, lined with periphyses. Ascocarp wall of textura angularis in surface view; in longitudinal section uniformly 12-18 µm thick, composed of 5-7 layers of small, compressed, hyaline-brown pseudoparenchymatous cells. Pseudoparaphyses 2.0-2.5 µm wide, numerous, narrowly cellular, branched and anatomosing to form a network, with septa at 11.5-15.2 µm intervals, with a slime coating. Asci numerous, in a broad hymenium, cylindrical-clavate, 170-185(215) x 24-26(28.5) µm, biseriate becoming uniseriate at base, rounded at apex with an apical chamber. Ascus endotunica showing zonation in congo red stain. Ascospores broadly fusiform, curved, 33-38(41) x 10-12 µm, 7-9 septate, evenly distributed, constricted at all septa, 4th cell from apex enlarged, dark reddish brown, with pale end cells, verruculose, with an amorphous gelatinous-mucilaginous sheath surrounding the entire spore.

Massariosphaeria massarioides was compared to the species described by Leuchtmann (1984) in his revision of the genus *Massariosphaeria*. Within the section having slot-like ostioles, it differs from *M. compositarum* (Mueller) Leuchtmann in having smaller, darker-colored, ornamented spores which

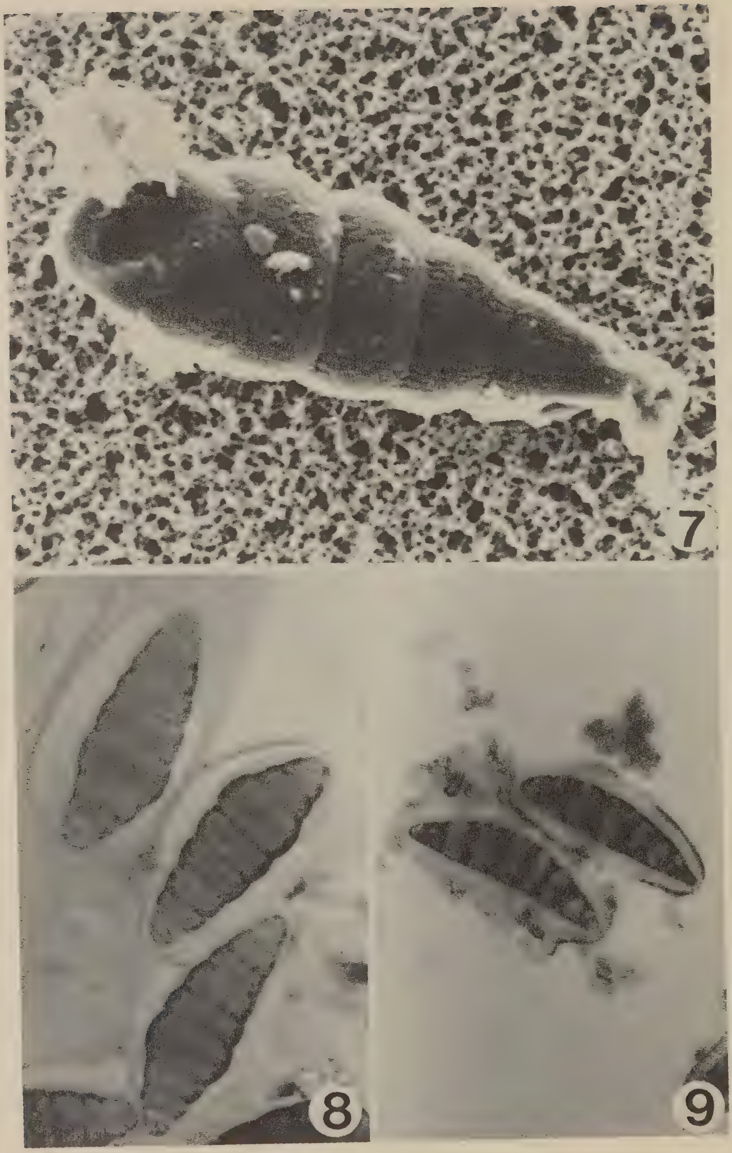




Figs. 1-2. *Massariosphaeria massarioides*. 1. Erumpent papilla with slot-like ostiole (arrow), by SEM. X450. 2. Longitudinal section through immersed fruit body showing dark, thickened apex. X250.



Figs. 3-6. *Massariosphaeria massarioides*. 3. Longitudinal section through ascocarp wall. X550. 4. Network of narrowly cellular pseudoparaphyses. X1740. 5. Ascus apex with an apical chamber. X2130. 6. Ascus endotunica stained with congo red showing zonation layers (arrow). X950.



Figs. 7-9. *Massariosphaeria massarioides*. 7. Ascospore showing verruculose ornamentation and sheath remnants, by SEM. X3300. 8, 9. Ascospores showing amorphous gelatinous sheaths. 8. X1080. 9. X940.

darken early within the ascus. From *M. grandispora* (Sacc.) Leuchtmann which is found on Gramineae, it differs in having wider spores with fewer septa and an Umbelliferous host. Several species of *Massariosphaeria* without slot-like ostioles also differ from *M. massarioides* in spore morphology, ascoma wall structure and having monocotyledonous hosts.

Massariosphaeria massarioides appears to have many of the same characteristics as the type species of the genus, *M. phaeospora* (Mueller) Crivelli. These include dark-brown, sculptured ascospores of similar size range and number of septa, a thick mucilaginous ascospore sheath and a fruit body with a wide papillate ostiole (Leuchtmann, 1984). It is distinct in that *M. phaeospora* is found on *Artemisia* and *Trisetum* in mountainous habitats whereas *M. massarioides* was found on *Heracleum*, habitat unknown. Mueller's (1950) illustration of *M. phaeospora* fruit body differs from *M. massarioides* in not having an erumpent papilla and Leuchtmann's (1984) description does not mention the presence of a slot-like ostiole. We cannot determine from the available descriptions whether *M. phaeospora* and *M. massarioides* are identical. Regrettably, attempts to obtain the type specimen of *M. phaeospora* have been unsuccessful. However, if the names are found to be synonymous, *M. massarioides* has priority. Cultural characteristics, pigment production and the anamorph of *M. massarioides* are unknown.

Recently, Barr (1989) reinstated *Chaetomastia* (Sacc.) Berlese as an older name for some species assigned to *Massariosphaeria* including *M. phaeospora*. Other species of *Massariosphaeria*, such as *M. compositarum* or *M. grandispora* were not included in *Chaetomastia* and have not yet been transferred out of the genus. If one regards *Massariosphaeria* as a synonym of *Chaetomastia* and *M. massarioides* is similar to *M. phaeospora*, then *M. massarioides* should be placed within *Chaetomastia*. However, if *M. massarioides* is similar to *M. compositarum* or *M. grandispora*, it could be transferred along with those species to another genus at a later time.

Acknowledgements

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AN EMENDED DESCRIPTION OF **FURIA CRUSTOSA** (ENTOMOPHTHORALES: ENTOMOPHTHORACEAE)

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ABSTRACT

Secondary conidia, cystidia and rhizoids of *Furia crustosa* (MacLeod & Tyrrell) Humber are described. The morphology of the cystidia and rhizoids supports the assignment of this species to the genus *Furia* (Batko) Humber. An emended description of *F. crustosa* is given.

INTRODUCTION

Furia crustosa (MacLeod & Tyrrell) Humber (Humber, 1989) was first described by MacLeod and Tyrrell (1979) under the name *Entomophthora crustosa* and later transferred to the genus *Erynia* by Humber and Ben–Ze'ev (1981), who pointed out that the description was incomplete in that it lacked an account of secondary conidia, cystidia and rhizoids, key features for allocation to sub–generic status within the genus *Erynia* as envisaged by them. More recently, it has been transferred to the genus *Furia* (Humber, 1989). Collection of fresh material in Northern Ontario has enabled us to obtain secondary conidia of this fungus, and detailed examination of dead insects bearing the conidial state of the fungus has revealed the presence of cystidia and monohyphal rhizoids. A description of these features and an emended description of *F. crustosa* are presented below.

MATERIALS.

Forest tent caterpillars, *Malacosoma disstria* Hbn. (Lepidoptera: Lasiocampidae) infected with *F. crustosa* were collected in the vicinity of New Liskeard, Ontario, approximately 125 km north of the type locality, on June 19 and 20, 1986. At death, insects were placed in 100 mm petri dishes with a moistened filter paper until sporulation occurred. Primary conidia were collected on the surface of water agar plates for 10–15 minutes. The plates containing primary conidia were inverted over a microscope slide and allowed to produce secondary conidia, a process which took 4–5 hours to complete. Secondary conidia were mounted in lactophenol/cotton blue. Fifty secondary conidia of each type were measured.

OBSERVATIONS.

Secondary Conidia.

Two types of secondary conidia were formed, both of which were uninucleate and actively discharged. One was identical in shape to the primary conidium (Type 1a, Ben–Ze'ev and Kenneth, 1982a), (Figs. 1, 2) and the other was "*muscae*" shape (Type 1b, as described for members of the subgenus *Neopandora* (Ben–Ze'ev and Kenneth, 1982a, 1982b) (= genus *Pandora*, [Humber, 1989]), (Figs. 3,4). Dimensions of these spores are given below. The two types of spores were produced together in variable ratios, but Type 1a tended to predominate; no factor governing production of either type was determined.

Figures 1–4. Secondary conidia of *Erynia crustosa*. 1,2. Type 1a secondary conidia, similar to primary conidia. 3,4. Type 1b "*muscae*" shape secondary conidia. Magnification x 300.

Figures 5,6. Cystidia of *Erynia crustosa*. 5. Phase contrast, unstained. 6. Stained with acetoorcein to show nuclei. Magnification x1320.

Figures 7–12. Development of monohyphal rhizoids in *Erynia crustosa*. 7. Initial stage showing swelling of rhizoid tip. 8. Development of branching at rhizoid tip. 9,10. Later stages of branching. 11,12. Mature rhizoids showing determinate ramified holdfast. Magnification x1280.

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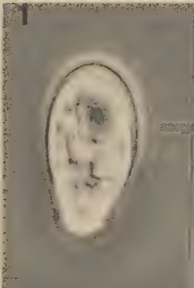

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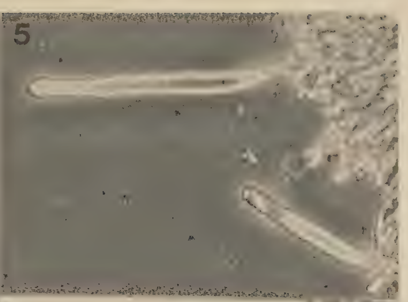

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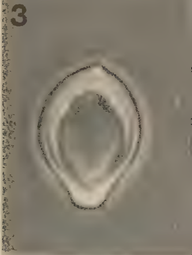

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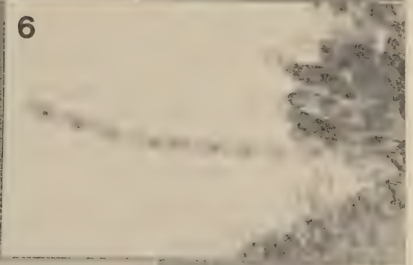

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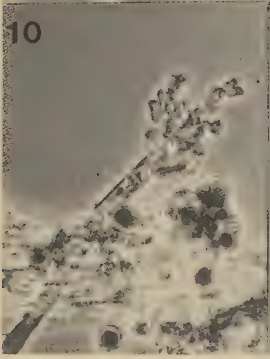

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Cystidia

Monohyphal cystidia were observed on cadavers that were producing conidia. They emerged prior to conidiophore emergence, were of the same diameter as hyphae and conidiophores and were occasionally up to 400 µm in length (Fig. 5). They were multinucleate (Fig. 6). As conidial production occurred and the conidiophores coalesced on the surface of the cadaver, the cystidia collapsed and were no longer visible.

Rhizoids

Rhizoids were observed on dead insects attached to their natural substrates (twigs) on which the fungus had completed sporulation. In one case, after transfer of a cadaver to a Petri dish, rhizoids continued to be produced and were clearly visualized on the bottom of the dish. Numerous monohyphal rhizoids (Ben–Ze'ev and Kenneth, 1979), which terminated in ramified holdfasts (Figs. 7–12), grew out of the ventral surface of infected larvae. There were many fascicles of entangled individual monohyphal rhizoids, but no compound holdfasts characteristic of true pseudorhizomorphs. Hyphae which grew out of the larval prolegs, as described by MacLeod and Tyrrell (1979), were observed in this study to be monohyphal rhizoids with terminally ramified holdfasts.

Generic classification.

The morphology of the cystidia and rhizoids of this fungus confirm its placement in the genus *Furia* (Humber, 1989), despite the fact that the conidiophores are digitately branched (MacLeod and Tyrrell, 1979), and thus more typical of the genus *Pandora* (Humber, 1989). In the production of two types of secondary conidia it resembles *P. neoaphidis*, the type species of *Pandora* (Remaudière and Hennebert, 1980). Thus, while production of a second type of secondary conidium differing in morphology from the primary is not mentioned in the generic diagnoses of either *Furia* or *Pandora*, (Humber, 1989), it is now evident that secondary conidia of Type 1b "*muscae*" shape can occur in both genera.

Furia crustosa, (MacLeod and Tyrrell, 1979), emended description.

Conidia oblong to ellipsoidal, with evenly rounded apex tapering to a papillate base, occasionally asymmetrical, 16.5 – 25.3 µm x 6.6 – 12.0 µm (av. 20.7 ± 1.8 µm x 9.6 ± 0.9 µm), hyaline, uninucleate, bitunicate; secondary conidia as primary, bitunicate, (Type 1a), 9.9 – 12.1 µm x 5.5 – 7.7 µm (av. 10.8 ± 0.8 µm x 7.0 ± 0.6 µm), or "*muscae*" shape (Type 1b), 12.1 – 15.4 µm x 8.8 – 15.4 µm (av. 13.9 ± 1.1 µm x 11.1 ± 1.3 µm); conidiophores branched, digitate, determinate; hyphal bodies variable, pyriform, oval or clavate (from which conidia are formed), or hypha–like (from which zygospores develop); zygospores spherical, variable, 20.9 – 41.8 µm (av. 28.9 ± 3.8 µm), sinuous in optical cross section, epispore undulate, cream to buff in mass, singly hyaline, formed by the fusion of two hypha–like hyphal bodies, and borne on a short neck from one of the gametangia; rhizoids monohyphal, terminating in ramified holdfasts, often entangled in fasicles, but not in true pseudorhizomorphs; cystidia hyphae–like, of same diameter as hyphae and conidiophores, tapering slightly towards the tip, up to 400 µm in length.

Acknowledgments.

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MELIOLACEOUS FUNGI FROM THE STATE OF KERALA, INDIA

II. The genus *Meliola*

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SUMMARY

This paper is the second on the meliolaceous fungi of Kerala, and gives an account of members of the genus *Meliola* collected in the Idukki Hydroelectric Project Area. Eighty-four species or infra-specific taxa collected in this study are listed; twenty-four of these were found to be undescribed species. These are described and illustrated. Twelve new varieties are recognized; these are also described and illustrated. New species described include the following: *M*. *ancistrocladii*, *M*. *atalantiae*, *M*. *atylosiae*, *M*. *buchananiicola*, *M*. *cansjericola*, *M*. *chandrasekharanii*, *M*. *clausenae*, *M*. *clitoriae*, *M*. *cycleae*, *M*. *dimidiatae*, *M*. *drypeticola*, *M*. *erycibis-paniculatae*, *M*. *erythropalii*, *M*. *hunteriae*, *M*. *ligustri*, *M*. *luvungae*, *M*. *nilgirianthii*, *M*. *otonephelii*, *M*. *premnicola*, *M*. *sarcostigmae*, *M*. *scleropyri*, *M*. *stemonuri*, *M*. *tylophorae*, and *M*. *wendlandiae*. New varieties include the following: *M*. *angiopteridis* var. *indica*, *M*. *bantamensis* var. *keralensis*, *M*. *beilschmiediae* var. *cinnamomicola*, *M*. *glochidii* var. *velutini*, *M*. *ixorae* var. *macrospora*, *M*. *litseae* var. *floribundae*, *M*. *litseae* var. *insignis*, *M*. *litseae* var. *keralense*, *M*. *mucunae* var. *hirsutae*, *M*. *rickiana* var. *zanthoxyli*, *M*. *salleana* var. *smilacis*, and *M*. *themedae* var. *indica*.

Key words: *Meliola*, Kerala, meliolaceous fungi, black mildews.

This is the second paper on the meliolaceous fungi found in the Idukki Hydroelectric Project Area of Kerala State, India, and reports, in part, the results of a systematic survey of meliolaceous fungi conducted during the years 1981-84 (Hosagoudar, 1987). A description of the study area was presented earlier and collections belonging to the genera *Amazonia*, *Armatella*, *Asteridiella* and *Irenopsis* were described or listed (Hosagoudar and Goos, 1989). This paper reports on members of the genus *Meliola*. Twenty-four collections were found to be undescribed species. These fungi are named, described and illustrated in this report. An additional twelve specimens were considered to represent new varieties; these are also described and illustrated. Collection and host records are given for all of the eighty-four taxa discussed. Types and representative materials are deposited in HCIO, New Delhi.

1. **Meliola acanthacearum** Hansf. var. *occidentalis* Hansf., Sydowia 11:50, 1957.

On leaves of *Rungia sisparensis* T. (Acanthaceae), Kanchiar forest, Dec. 29, 1983, V.B. Hosagoudar, HCIO 40491; MH 80352.

2. **Meliola aglaicola** Hansf., Reinwardtia 3:92, 1954.

On leaves of *Aglaia minutiflora* Bedd. (Meliaceae), Pamba, Oct. 12, 1983, V.B. Hosagoudar, HCIO 40492; MH 78955.

3. **Meliola alstoniae** Koord., Verhandl. K. Akad. Wetensch. Amsterdam 13:170, 1907.

On leaves of *Alstonia scholaris* (L.) R. Br. (Apocynaceae), Lakshmi Estate, Dec. 15, 1982, V.B. Hosagoudar, HCIO 40493; MH 75768.

4. **Meliola anceps** H. Sydow & P. Sydow, Ann. Mycol. 14:76, 1916.

On leaves of *Mussaenda laxa* Hutch. (Rubiaceae), Idukki, Oct. 8, 1983, V.B. Hosagoudar MH 78906; Dec. 23, 1983. V.B. Hosagoudar, HCIO 40494; MH 79030.

5. **Meliola ancistrocladii** Hosagoudar, sp. nov. Fig. 1.

Plagulae hypophyllae raro epiphyllae, densae, usque 10 mm diam., confluentes. Hyphae subrectae vel undulatae, plerumque opposite acuteque vel lateque ramosae, laxe reticulatae, cellulis 16-20 x 4-7 µm. Hyphopodia capitata alternata vel usque 10% opposita, recta vel curvula, antrorsa vel patentia, 12-20 um longa; cellula basali cylindracea vel cuneata, 3-6.5 µm longa; cellula apicali ovata vel globosa, integra, 10-13 µm. Hyphopodia mucronata et capitatis commixta, opposita vel alternata, ampullacea, 16.5-26.5 x 10-13 µm. Setae myceliales tenuiter dispersae, rectae vel flexuosae, simplices, acutae vel obtusae usque apices, usque 291 µm longae. Perithecia pauca, dispersa, usque 165 µm; sporae obovatae, 4-septatae, constrictae, 33-36.5 x 13-15 µm.

Colonies hypophyllous, rarely epiphyllous, dense, up to 10 mm in diameter, confluent. Hyphae substraight to undulating, branching mostly opposite at acute to wide angles, loosely reticulate, cells 16-20 x 4-7 µm. Capitate hyphopodia alternate to about 10% opposite, straight to curved, antrorse to spreading, 12-20 µm long; stalk cells cylindrical to cuneate, 3-6.5 µm long; head cells ovate to globose, entire, 10-13 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 16.5-26.5 x 10-13 µm. Mycelial setae fairly numerous, equally scattered, straight to flexuous, simple, acute to obtuse at the tip, up to 291 µm long. Perithecia few, scattered, up to 165 µm; spores obovate, 4-septate, constricted, 33-36.5 x 13-15 µm.

Holotype: On leaves of Ancistrocladus heyneanus Wall. ex Grah. (Ancistrocladaceae), Idukki, Oct. 2, 1983, V.B. Hosagoudar, HCIO 40495; MH 78107, Isotype.

To date, there is no record of meliolaceous fungi on the members of the family Ancistrocladaceae (Stevenson, 1968).

6. **Meliola angiopteridis** Hansf. var. **indica** Hosagoudar, var. nov. Fig. 2.

Differt a M. angiopteridis Hansf. var. angiopteridis plagulis hypophyllis tenuibus, hyphis subrectis usque undulatis, hyphopodiis capitatis oppositis nullis.

Colonies hypophyllous, thin, up to 5 mm in diameter, confluent. Hyphae straight to undulating, branching opposite to irregular at wide angles, loosely reticulate, cells 20-30 x 6-8 µm. Capitate hyphopodia alternate to unilateral, scattered, antrorse to reflexed, straight to curved, 14-20 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells ovate, entire, often curved, 10-14 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 20-26 x 6-8 µm. Mycelial setae straight, simple, acute at the tip, up to 460 µm long. Perithecia scattered, verrucose, up to 200 µm; spores ellipsoidal, 4-septate, constricted, 36-40 x 12-16 µm.

Holotype: On leaves of Angiopteris evecta (Forst.) Hoff. (Angiopteridaceae), Idukki, Feb. 20, 1984, B. Rajeevan, HCIO 40498; MH 80364, Isotype.

Hansford (1954) described M. angiopteridis from Java and Sumatra on Angiopteris evecta (Forst.) Hoffm. The present variety differs from the type variety in forming thin, hypophyllous colonies, having substraight to undulating hyphae and in the absence of opposite capitate hyphopodia.

7. **Meliola atalantiae** Hosagoudar, sp. nov. Fig. 3.

Plagulae amphigenae, plerumque hypophyllae, crustosae, usque 8 mm diam., raro confluentes. Hyphae brunneae, rectae vel subrectae vel anfractae, opposite vel iregulariter acuteque ramosae, laxe reticulatae, cellulis 20-28 x 6-8 µm. Hyphopodia capitata alternata vel usque ad 20% opposita, recta vel curvula, subantrorsa vel patentia, 20-30 µm longa; cellula basali cuneata vel cylindracea, 4-10 µm longa; cellula apicali ovata, conoidea, apice rotundata, integra, 14-20 x 8-10 µm. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, 20-26 x 8-12 µm. Setae myceliales dispersae, rectae, raro curvulae, simplices, acutae vel 2-3 dentatae vel cristatae, usque 765 µm longae. Perithecia dispersa, usque 160 µm; sporae oblongae, 4-septatae, constrictae, 40-44 x 14-16 µm.

Colonies amphigenous, mostly hypophyllous, crustaceous, up to 8 mm in diameter, rarely confluent. Hyphae straight to substraight to crooked, branching opposite to irregular at acute angles, loosely reticulate, cells 20-28 x 6-8 µm. Capitate hyphopodia alternate, about 20% opposite, straight to curved, subantrorse to spreading, 20-30 µm long; stalk cells cylindrical to cuneate, 4-10 µm long; head cells ovate, conoid, rounded at the apex, entire, 14-20 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 20-26 x 8-12 µm. Mycelial setae scattered, straight, often curved, simple, acute to 2-3 dentate to cristate, up to 765 µm long. Perithecia scattered, up to 160 µm; spores oblong, 4-septate, constricted, 40-44 x 14-16 µm.

Holotype: On leaves of *Atalantia wightii* Tanaka (Rutaceae), near Painavu, Feb. 19, 1983, V.B. Hosagoudar HCIO 40496; MH 75855, Isotype. Paratype: Idukki, Dec. 12, 1982, V.B. Hosagoudar MH 75705. On leaves of *A. ceylonica* Olive, near Painavu, Feb. 22, 1984, M. Ali, MH 80369.

Uppal *et al*. (1935) listed an unidentified species of *Meliola* on *Atalantia racemosa* Wight & Arn. from Maharashtra. *Meliola tenella* Pat. var. *atalantiae* (Pat.) Hansf. has been recorded on *Atalantia* from Tonkin, Ceylon, Formosa and the Philippines (Hansf., 1961). The present species differs from it mainly in having simple setae in contrast to dichotomously branched ones, and in having smaller ascospores.

8. **Meliola atylosiae** Hosagoudar, sp. nov. Fig. 4.

Plagulae epiphyllae, subdensae vel densae, ad 2 mm diam. Hyphae undulatae, oppositae vel alternatae acuteque ramosae, laxe reticulatae, cellulis 12-22 x 4-8 µm. Hyphopodia capitata opposita vel alternata (3:1), recta, patentia, antrorsa, 12-16 µm longa; cellula basali cylindracea vel cuneata, 4-6 µm longa; cellula apicali globosa, integra, apice leniter late rotundata, 8-10 x 10-12 µm. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, 16-20 x 6-10 µm. Setae myceliales paucae, dispersae, simplices, dentatae, ad 270 um longae. Perithecia dispersa vel aggregata, verrucosa, ad 140 µm; sporae oblongae vel obovoidae, 4-septatae, constrictae, 34-40 x 10-14 µm.

Colonies epiphyllous, subdense to dense, up to 2 mm in diameter. Hyphae undulating, branching opposite to alternate at acute angles, loosely reticulate, cells 12-22 x 4-8 µm. Capitate hyphopodia opposite and alternate (3:1), straight, spreading, antrorse, 12-16 µm long; stalk cells cylindrical to cuneate, 4-6 µm long; head cells globose, entire, slightly and bluntly pointed towards the apex, 8-10 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 16-20 x 6-10 µm. Mycelial setae few, scattered, simple, variously dentate at the apex, up to 270 µm long. Perithecia scattered to grouped, verrucose, up to 140 um; spores oblong to obovoidal, 4-septate, constricted, 34-40 x 10-14 µm.

Holotype: On leaves of Atylosia lineata Wight & Arn. (Papilionaceae), Idukki, Dec. 23, 1983, V.B. Hosagoudar, HCIO 40497; MH 79035, Isotype.

This species is close to Meliola bicornis Wint. but differs from it in the infection pattern, and in the morphology of the mycelium and capitate hyphopodia. Further, there is no record of meliolaceous fungi on this host genus.

9. **Meliola bantamensis** Hansf. var. **keralensis** Hosagoudar, var. nov. Fig. 5

Differt a M. bantamensis Hansf. var. bantamensis setis myceliorum brevioribus et ascosporis magnioribus.

Colonies epiphyllous, rarely caulicolous and amphigenous, thin to subvelvety, up to 3 mm in diameter, confluent. Hyphae tortuous, branching opposite to irregular at acute to wide angles, loosely to closely reticulate, cells 18-36 x 6-8 µm. Capitate hyphopodia alternate to unilateral (very few opposite), spreading, antrorse, 14-20 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells globose to subglobose, angulose to shallowely lobate, often curved, 8-12 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 10-22 x 4-8 µm. Mycelial setae scattered, straight, simple, acute at the tip, up to 288 µm long. Perithecia scattered, verrucose, up to 166 µm; spores oblong, 4-septate, 34-50 x 12-18 µm.

Holotype: On leaves of Desmodium gyrans DC. (Papilionaceae), Meenumutty, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40499. Paratype: Meenumutty, Dec. 12, 1983, V.B. Hosagoudar, MH 78988.

So far, 12 species of the genus Meliola have been recorded on the host genus Desmodium (Hansford, 1961). Based on the nature of the hyphae, capitate hyphopodia and ascospore measurements, the cited collections are closer to M. bantamensis Hansf., but differ from the var. bantamensis in having shorter mycelial setae and larger ascospores.

10. **Meliola bataanensis** H. Sydow & P. Sydow, Ann. Mycol. 12:551, 1914.

On leaves of Milletia rubiginosa Wight & Arn. (Papilionaceae), Idukki, April 18, 1982, V.B. Hosagoudar, HCIO 40500; MH 73705; Meenumutty, April 19, 1982, V.B. Hosagoudar, MH 73709; Painavu, Dec. 22, 1983, V.B. Hosagoudar, MH 78996; Idukki, Feb. 23, 1984, M. Ali, MH 80368.

11. **Meliola beilschmiediae** Yamam. var. cinnamomicola Hosagoudar, var. nov. Fig. 6.

Differt a M. beilschmiediae Yamam. var. beilschmiediae. Plagulis densis, hyphopodiis capitatis brevibus, setis mycelii brevibus et dentatis.

Colonies hypophyllous, dense, velvety, up to 5 mm in diameter, rarely confluent. Hyphae flexuous, branching alternate to irregular at acute angles, closely reticulate, forming an almost solid mycelial mat, cells 20-30 x 6-8 µm. Capitate hyphopodia alternate, straight to variously curved, antrorse to reflexed, 20-24 µm long; stalk cells cylindrical to cuneate, 6-10 µm long; head cells globose, ovate, angular, entire, 14-16 x 12-14 µm. Mucronate hyphopodia few, mixed with capitate hyphopodia, opposite to alternate, ampulliform, 18-22 x 8-10 µm. Mycelial setae numerous, evenly scattered, straight, simple, acute to variously dentate at the tip, up to 684 µm long. Perithecia closely scattered, verrucose, up to 216 µm; spores obovoidal, 4-septate, slightly constricted, 54-60 x 12-20 µm.

Holotype: On leaves of Cinnamomum malabatrum (Burm. f.) Blume (Lauraceae), Calvary Mount, Oct. 5, 1983, V.B. Hosagoudar MH 78160. Isotype: In HCIO No. 34973. Paratypes: Calvary Mount, June 14, 1982, V.B. Hosagoudar, MH 79012; Dec. 13, 1982, V.B. Hosagoudar, MH 75741; Feb. 21, 1983, V.B. Hosagoudar, MH 75833; Lakshmi Estate, June 12, 1983, V.B. Hosagoudar, MH 75081; Idukki, Oct. 5, 1983, V.B. Hosagoudar, MH 78159; Pamba, Oct. 11, 1983, V.B. Hosagoudar, MH 78940; Idukki, Dec. 21, 1983, V.B. Hosagoudar, MH 78970.

Hansford (1954) described Meliola beilschmiediae Yamam. var. cinnamomi Hansf. on Cinnamomum iners Reinw. ex

Bl. from Java. The new variety differs from M. beilschmiediae Yamam. var. cinnamomi Hansf. in forming dense colonies, and in having shorter capitate hyphopodia, and shorter, dentate, mycelial setae.

This variety was mostly found with Armatella cinnamomicola Hansf.

12. **Meliola buchananiicola** Hosagoudar, sp. nov. Fig. 7.

Plagulae hypophyllae, subdensae vel densae, ad 8 mm diam., confluentes. Hyphae mycelii tortuosae, opposite vel irregulariter acuteque vel laxe ramosae, densae reticulatae et solidae, cellulis 20-38 x 6-10 µm. Hyphopodia capitata alternata, recta vel curvula, patentia, antrorsa, reflexa, 36-50 µm longa; cellula basali cylindracea, cuneata vel tortuosa, 14-22 µm longa; cellula apicali ovala, globosa, angulosa, integra vel sublobata, recta vel curvula, 22-30 x 12-16 µm. Hyphopodia mucronata pauca, illis capitatis commixta, opposita vel alternata, conoidea vel ampullacea, 14-22 x 6-8 µm. Setae myceliales numerosae, simplices, acutae vel obtusae, ad 954 µm longae. Perithecia dispersa, verrucosa, ad 234 µm; sporae obovoidae vel cylindraceae, 4-septatae, constrictae, 42-50 x 14-18 µm.

Colonies hypophyllous, subdense to dense, up to 8 mm in diam., confluent. Hyphae tortuous, branching opposite to irregular at acute to wide angles, closely reticulate and form almost solid mycelial mat, cells 20-38 x 6-10 µm. Capitate hyphopodia alternate, straight to variously curved, antrose to reflexed, 36-50 µm long; stalk cells cylindrical to cuneate, often tortuous, 14-22 µm long; head cells ovate, globose, angulose, sublobate, straight to variously curved, 22-30 x 12-16 µm. Mucronate hyphopodia few, mixed with capitate hyphopodia, opposite to alternate, conoid to ampulliform, 14-22 x 6-8 µm. Mycelial setae numerous, simple, acute to obtuse at the tip, up to 954 µm long. Perithecia scattered, verrucose, up to 234 µm; spores obovoidal to cylindrical, 4-septate, constricted, 42-50 x 14-18 µm.

Holotype: On the leaves of Buchanania lanzan Sprengel (Anacardiaceae), Calvary Mount, Dec. 14, 1982, V.B. Hosagoudar, HCIO 40501; MH 75750, Isotype.

The present species can be compared with M. buchananiae Stev. ex Hansf. and M. hamata H. Sydow & P. Sydow (Hansf., 1961). It differs from the former in having flexuous stalk cells of the capitate hyphopodia, longer mycelial setae and smaller ascospores. It differs from the latter species in having larger capitate hyphopodia, flexuous stalk cells of the capitate hyphopodia, and larger mycelial setae.

13. **Meliola buteae** Hafiz, Azmatullah & Kafi, Biologia 1:112, 1955.

On leaves of Butea monosperma (Lam.) Taub. (Papilionaceae), Idukki, Oct. 9, 1982, V.B. Hosagoudar, HCIO 40502; MH 73797; Oct. 4, 1983, V.B. Hosagoudar, MH 78145. On leaves of B. parviflora Roxb., Vellakayam, Feb. 24, 1983, M. Ali & C.N. Mohanan, MH 75010.

14. **Meliola cansjericola** Hosagoudar, sp. nov. Fig. 8.

Plagulae amphigenae, subdensae vel densae, velutinae, ad 4 mm diam., confluentes. Hyphae rectae vel subrectae vel leniter undulatae, alternate acuteque ramosae, laxe vel densae reticulatae, cellulis 24-32 x 7-8 µm. Hyphopodia capitata alternata, antrorsa, patentia, 30-42 µm longa; cellula basali cylindracea vel cuneata, 10-12 µm longa; cellula apicali ovata, globosa, sublobata vel stellate lobata, 12-24 x 20-26 µm. Hyphopodia mucronata pauca, illis capitatis commixta, alternata, ampullacea, 18-20 x 8-10 µm. Setae myceliales juxta perithecia aggregatae, simplices, acutae, ad 835 µm longae. Perithecia dispersa, verrucosa, ad 324 µm; sporae fusiformae, rectae vel curvulae, 3-septatae, cellulae terminalis subacuminatae, 48-60 x 18-22 µm.

Colonies amphigenous, subdense to dense, velvety, up to 4 mm in diameter, confluent. Hyphae straight to slightly undulating, branching alternate at acute angles, loosely to closely reticulate, cells 24-32 x 7-8 µm. Capitate hyphopodia alternate, antrorse, spreading, 30-42 µm long; stalk cells cylindrical to cuneate, 10-12 µm long; head cells ovate, globose, sublobate to stellately lobate, 12-24 x 20-26 µm. Mucronata hyphopodia few, mixed with capitate hyphopodia, alternate, ampulliform, 18-20 x 8-10 µm. Mycelial setae mostly grouped around perithecia, simple, acute at the tip, up to 835 µm long. Perithecia scattered, verrucose, up to 324 µm; spores fusiform, straight to curved, 3-septate, end cells conoid, 48-60 x 18-22 µm.

Holotype: On leaves of Cansjera rheedii Gamble (Opiliaceae), Calvary Mount, Jan. 8, 1982, V.B. Hosagoudar, HCIO 40503; MH 72606, Isotype.

Hansfsord & Thirumalachar (1948) described Meliola cansjerae on Cansjera rheedii Gamble from Karnataka, India. This species differs from it in having 3-septate ascospores, strictly alternate capitate hyphopodia, stellately lobed head cells of the capitate hyphopodia, simple and acute mycelial setae.

15. **Meliola capensis** (K. & C.) Theiss. var. **malayensis** Hansf., Sydowia 10:67, 1957.

On leaves of Nephelium longan Lour. (Sapindaceae), Painavu, April 4, 1982, V.B. Hosagoudar, HCIO 40504; MH 72698; Idukki, Dec. 23, 1983, V.B. Hosagoudar, MH 79041.

16. **Meliola chandleri** Hansf., Journ. Linn. Soc. London 51:271, 1937.

On leaves of Excoecaria crenulata Wight, (Euphorbiaceae), Kanchiar forest, Dec. 29, 1983, V.B. Hosagoudar, HCIO 40505; MH 80338.

17. **Meliola chandrasekharanii** Hosagoudar, sp. nov. Fig. 9.

Plagulae amphigenae, caulicolae, plerumque hypophyllae, subdensae, velutinae, ad 3 mm diam., confluentes. Hyphae undulatae, oppositae acuteque ramosae, laxe vel densae reticulatae et solidae, cellulis 16-30 x 6-8 µm. Hyphopodia capitata alternata (rarissime opposita), recta vel curvula, patentia, plerumque antrorsa, 16-24 µm longa; cellula basali cuneata vel cylindracea, 4-10 µm longa; cellula apicali subglobosa, ovata, angulosa, sublobata, 12-16 x 12-14 µm. Hyphopodia mucronata in hyphis distinctis evoluta, pauca illis capitatis commixta, alternata, plerumque opposita, ampullacea, 12-20 x 6-10 µm. Setae myceliales subnumerosae, rectae, simplices, acutae vel subacutae, ad 477 µm longae. Perithecia dispersa, verrucosa, ad 153 µm; sporae obovoidae vel cylindraceae, 4-septatae, constrictae, 32-42 x 10-16 µm.

Colonies amphigenous, caulicolous, mostly hypophyllous, subdense, velvety, up to 3 mm diameter, confluent. Hyphae undulating, branching opposite at acute angles, loosely to closely reticulate and form almost solid mycelial mat, cells 16-30 x 6-8 µm. Capitate hyphopodia alternate (few opposite), straight to curved, spreading, mostly antrorse, 16-24 µm long; stalk cells cuneate to cylindrical, 4-10 µm long; head cells subglobose, ovate, angular to sublobate, 12-14 x 12-16 µm. Mucronate hyphopodia borne on a separate mycelial branch, few mixed with capitate hyphopodia, alternate, mostly opposite, ampulliform, 12-20 x 6-10 µm. Mycelial setae fairly numerous, straight, simple, acute to subacute at the tip, up to 477 µm long. Perithecia scattered, verrucose, up to 153 µm; spores obovoidal to cylindrical, 4-septate, constricted, 32-42 x 10-16 µm.

Holotype: On leaves, stems and petioles of Apodytes beddomei Mask (Icacinaceae), Lakshmi Estate, Dec. 15, 1982, V.B. Hosagoudar, HCIO 40506; MH 75781, Isotype. Paratype: Lakshmi Estate, Dec. 25, 1983, V.B. Hosagoudar, MH 79089.

So far three species of Meliola have been recorded on Apodytes (Hansf., 1961). This species differs from them in having straight and subacute mycelial setae, and entire to sublobate head cells of the capitate hyphopodia. It also differs from M. dimidiatae sp. nov. in formation of the amphigenous and caulicolous colonies, and entire to sublobate head cells of the capitate hyphopodia.

The species is named in honour of my (V.B.H.) teacher, Dr. Chandrasekharan Nair.

18. **Meliola citricola** H. Sydow & P. Sydow, Ann. Mycol. 15:183, 1917.

On leaves of Citrus aurantium L. (Rutaceae), Calvary Mount, Dec. 14, 1982, V.B. Hosagoudar, HCIO 40567; MH 75752; Vazhathope, April 21, 1982, V.B. Hosagoudar, MH 73743.

19. **Meliola clausenae** Hosagoudar, sp. nov. Fig. 10.

Plagulae epiphyllae, tenues, ad 2 mm diam. Hyphae brunneae, rectae vel leniter undulatae, oppositae lateque ramosae, laxe reticulatae, cellulis 10-16 x 6-8 µm. Hyphopodia capitata alternata vel 20% opposita, recta vel curvula, plus minusve antrorsa, 16-24 µm longa; cellula basali cuneata vel cylindracea, 6-8 µm longa; cellula apicali cylindracea, ovata, integra, 10-16 x 8-10 µm. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, 12-20 x 6-8 µm. Setae myceliales dispersae, rectae, simplices, acutae vel 2-3 dentatae, ad 747 µm longae. Perithecia dispersa, verrucosa, ad 180 um; sporae obovoidae, 4-septatae, constrictae, 36-42 x 14-16 µm.

Colonies epiphyllous, thin, up to 2 mm in diameter. Hyphae straight to slightly undulating, branching opposite at wide angles, loosely reticulate, cells 10-16 x 6-8 µm. Capitate hyphopodia alternate, 20% opposite, straight to curved, subantrorse to antrorse, 16-24 µm long; stalk cells cylindrical to cuneate, 6-8 µm long; head cells cylindrical, ovate, entire, 10-16 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 12-20 x 6-8 µm. Mycelial setae scattered, straight, simple, acute to 2-3 dentate, up to 747 µm long. Perithecia scattered, verrucose, up to 180 µm; spores obovoid, 4-septate, constricted, 36-42 x 14-16 µm.

Holotype: On leaves of Clausena indica (Dalz.) Oliver (Rutaceae), Kanchiar forest, Feb. 23, 1983, V.B. Hosagoudar, HCIO 40508; MH 75009, Isotype.

This species is close to M. citricola H. Sydow & Sydow but mainly differs from it in the pattern of infection. There is no earlier record of the genus Meliola on this host genus, hence it is proposed here as a new species.

20. **Meliola clavulata** Wint., Hedwigia 25: 98, 1886.

On leaves of Argyeria populifolia Chois. (Convolvulaceae), Vazhathope, Jan. 7, 1982, V. B. Hosagoudar, HCIO 40509; MH 71582.

This species was mixed with the colonies of Meliola malacotricha Speg. var. major Beeli.

21. **Meliola clerodendricola** P. Henn., Hedwigia 37: 288, 1895.

On leaves of Clerodendrum viscosum Vent. (Verbenaceae), Idukki, Dec. 21, 1983, V. B. Hosagoudar, HCIO 40510; MH 78959; Feb. 18, 1983, V. B. Hosagoudar, MH 75847; Oct. 24, 1984, A. Diraviadoss, MH 82606.

22. **Meliola clerodendricola** P. Henn. var. **micromera** (Syd.) Hansf., Sydowia Beih. 2: 694, 1961.

On leaves of Gmelina arborea Roxb. (Verbenaceae), Calvary Mount, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40511; MH 73690; Painavu, Dec. 12, 1983, V. B. Hosagoudar MH 78979; Oct. 3, 1983, V.B. Hosagoudar MH 78126.

23. **Meliola clitoriae** Hosagoudar, sp. nov. Fig. 11.

Plagulae amphigenae, plerumque epiphyllae, ad 2 mm diam., confluentes. Hyphae subrectae vel leniter undulatae, opposite acuteque ramosae, laxe reticulatae, cellulis 24-38 x 6-8 µm. Hyphopodia capitata alternata, unilateralia vel ad 5% opposita, recta vel curvula, patentia, antrorsa vel reflexa, 12-20 µm longa; cellula basali cylindracea vel cuneata, 4-8 µm longa; cellula apicali globosa, recta vel curvula, 8-12 µm. Hyphododia mucronata illis capitatis commixta vel in hyphis distinctis evoluta, alternata vel opposita, ampullacea, 16-24 x 8-12 µm. Setae myceliales dispersae vel juxta perithecia aggregatae, simplices, rectae, acutae, ad 450 µm longae. Perithecia dispersa, verrucosa, ad 180 µm; sporae oblongae, 4-septatae, constrictae, 36-42 x 12-14 µm.

Colonies amphigenous, mostly epiphyllous, subdense, up to 2 mm in diameter, confluent. Hyphae substraight to slightly undulating, branching opposite at acute angles, loosely reticulate, cells 24-38 x 6-8 µm. Capitate hyphopodia alternate, unilateral to 5% opposite, straight to curved, spreading, antrorse to reflexed, 12-20 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells globose, entire, straight to curved, 8-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia and borne on a separate mycelial branch, alternate to opposite, ampulliform, 16-24 x 8-12 µm. Mycelial setae scattered to grouped around perithecia, simple, straight, acute at the tip, up to 450 µm long. Perithecia scattered, verrucose, up to 180 µm; spores oblong, 4-septate, constricted, 36-42 x 12-14 µm.

Holotype: On leaves, stems and petioles of Clitoria turnatea L. (Papilionaceae), Puliyanmala Tea Estate, Dec. 15, 1983, V. B. Hosagoudar, HCIO 40512; MH 79093, Isotype.

Meliola bicornis Wint. has been recorded on Clitoria rubiginosa A. Juss. ex Pers. from Jamaica (Hansf., 1961). Meliola clitoriae differs in size and in having mucronate hyphopodia mixed with the capitate hyphopodia, borne on a separate mycelial branches.

24. **Meliola coilicosa** Nair & Kaul, Sydowia 36: 204, 1983.

On leaves of Canthium dicoccum (Gaertn.) Teys & Benn. (Rubiaceae), Idukki, Feb. 18, 1983, V.B. Hosagoudar, HCIO 40513; MH 75846.

25. **Meliola commixta** H. Sydow, Leafl. Philipp. Bot. 9: 3117, 1925.

On leaves of Nephelium longan Lour. (Sapindaceae), Idukki, Oct. 9, 1982, V. B. Hosagoudar, HCIO 40514; MH 73601.

26. **Meliola connari** Yates, Philipp. Journ. Sci. C., Botany 12: 364, 1917.

On leaves of Connarus sclerocarpus Schell. (Connaraceae), Idukki, Feb. 25, 1983, V. B. Hosagoudar, HCIO 40515; MH 75020; Feb. 20, 1983, V. B. Hosagoudar, MH 75866.

This collection differs slightly from the description in having hypophyllous colonies, smaller capitate hyphopodia, and mycelial setae.

27. **Meliola cycleae** Hosagoudar, sp. nov. Fig. 12.

Plagulae amphigenae, plerumque epiphyllae, subdensae vel densae, ad 3 mm diam., confluentes. Hyphae subrectae vel undulatae, opposite vel irregulariter acuteque ramosae, laxe vel dense reticulatae, cellulis 16-28 x 6-8 µm. Hyphopodia capitata alternata vel unilateralia, recta, antrorsa, 20-28 µm longa; cellula basali cuneata, 6-12 µm longa; cellula apicali ovalis, versiformis, apice late rotundata, integera, 14-18 x 12-14 µm. Hyphopodia mucronata in hyphis distinctis evoluta, alternata vel opposita, conoidea vel ampullacea, 14-22 x 6-8 µm. Setae myceliales dispersae et juxta perithecia aggregatae, simplices, acutae, ad 432 µm longae. Perithecia dispersa, verrucosa, ad 160 µm; sporae oblongae, 4-septatae, leniter constrictae, 34-40 x 16-20 µm.

Colonies amphigenous, mostly epiphyllous, subdense to dense, up to 3 mm in diameter, confluent. Hyphae substraight to slightly undulating, branching opposite to irregular at acute angles, loosely to closely reticulate, cells 16-28 x 6-8 µm. Capitate hyphopodia alternate to unilateral, straight to antrorse, 20-28 µm long; stalk cells cuneate, 6-12 µm long; head cells ovate, versiform, slightly and bluntly pointed at the apex, entire, 14-18 x 12-14 µm. Mucronate hyphopodia borne on a separate mycelial branch, alternate to opposite, conoid to ampulliform, 14-22 x 6-8 µm. Mycelial setae scattered to grouped around the perithecia, simple, acute at the tip, up to 432 µm long. Perithecia scattered, verrucose, up to 160 µm; spores oblong, 4-septate, slightly constricted, 34-40 x 16-20 µm.

Holotype: On leaves, stem and petioles of Cyclea peltata Cooke (Menispermaceae), Meenumutty, Dec. 12, 1982, V. B. Hosagoudar, HCIO 40516; MH 73696, Isotype.

Meliola cycleae is close to M. cissampelicola Hansf. & Thirum., but differs in the infection pattern, in having dense colonies, and longer mycelial setae. Further, there is no record of the genus Meliola on this host genus.

28. **Meliola cymbopogonis** Kapoor, Indian Phytopath. 20: 152, 1967.

On leaves of Cymbopogon flexuosus Wats (Gramineae), Vazhathope, Idukki, March 26, 1983, V. B. Hosagoudar, HCIO 40517; MH 75038; Meenumutty, Idukki, Kerala, Aug. 20, 1983, V. B. Hosagoudar, MH 75879; Idukki, Kerala, Oct. 4, 1983, V. B. Hosagoudar, MH 78152; Dec. 4, 1983, V. B. Hosagoudar, HCIO 34972.

29. **Meliola densa** Cooke, Grevillea 12:85, 1884.

On leaves of Syzygium munroni (Walp.) Chandr. (Myrtaceae), Idukki, Feb. 18, 1983, V.B. Hosagoudar, HCIO 40518; MH 75027; Feb. 25, 1983, V.B. Hosagoudar, MH 75833, 79028. On leaves of S. laetum (Buch. - Ham.) Gandhi, Idukki, Dec. 12, 1982, V.B. Hosagoudar, MH 75715.

31. **Meliola dimidiatae** Hosagoudar, sp. nov. Fig. 13.

Plagulae epiphyllae, subdensae, subvelutinae, dispersae, ad 3 mm diam., raro confluentes. Hyphae brunneae, flexuosae, opposite vel irregulariter acuteque ramosae, laxe reticulatae, cellulis 16-24 x 6-8 µm. Hyphopodia capitata alternata vel unilateralia (raro opposita), recta vel curvula, antrorsa vel reflexa, patentia, 16-20 µm longa; cellula basali cylindracea vel cuneata, 4-6 µm longa; cellula apicali plerumque globosa, ovata, curvula, integra, 12-14 x 10-12 µm. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, 20-26 x 8-10 µm. Setae myceliales numerosae, dispersae vel usque juxta perithecia aggregatae, rectae, simplices, acutae, ad 540 µm. Perithecia dispersa, verrucosa, ad 180 µm; sporae cylindraceae, 4-septatae, constrictae, 42-44 x 16-18 µm.

Colonies epiphyllous, subdense, subvelvety, scattered, up to 3 mm in diameter, rarely confluent. Hyphae flexuous, branching opposite to irregular at acute angles, loosely reticulate, cells 16-24 x 6-8 µm. Capitate hyphopodia alternate and unilateral (few opposite), straight to curved, antrorse to reflexed, spreading, 16-20 µm long; stalk cells cylindrical to cuneate, 4-6 µm long; head cells mostly globose, ovate, curved, entire 12-14 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 20-26 x 8-10 µm. Mycelial setae numerous, scattered, often grouped around perithecia, straight, simple, acute, up to 540 µm long.

Spores cylindrical, 4-septate, constricted, 42-44 x 16-18 µm.

Holotype: On leaves of Apodytes dimidiata E. Meyer ex Arn. (Icacinaceae), Idukki, Oct. 4, 1983, V.B. Hosagoudar, HCIO 40519; MH 78141, Isotype. Paratype: Lakshmi Estate, Dec. 15, 1982, V.B. Hosagoudar, MH 75781.

So far three species of Meliola, namely M. apodytes van der Bijl., M. campylotricha Syd. and M. cladophila Syd., have been recorded on this host genus (Hansf., 1961). The present species differs from all others in having globose head cells of the capitate hyphopodia, straight mycelial setae and 4-septate ascospores. It also differs from M. chandrasekharanii sp. nov. (this paper) in the formation of epiphyllous colonies, and in the entire and globose head cells of the capitate hyphopodia.

31. **Meliola diospyri** H. Sydow, Ann. Mycol. 9:381, 1911.

On leaves of Diospyros sylvatica Roxb. (Ebenaceae), Calvary Mount, Oct. 5, 1983, V.B. Hosagoudar, HCIO 40520; MH 78169.

The collection cited varies slightly from the description in having larger capitate hyphopodia, mycelial setae and ascospores.

32. **Meliola drypeticola** Hosagoudar, sp. nov. Fig. 14.

Plagulae hypophyllae, dispersae, densae, velutinae, ad 10 mm diam., confluentes. Hyphae mycelii rectae vel undulatae, brunneae, opposite vel irregulariter lateque ramosae, laxe reticulatae, cellulis plerumque 24-30 x 6-8 µm. Hyphopodia capitata alternata vel usque ad 10% opposita, recta, patentia, antrorsa vel reflexa, 12-16 µm longa; cellula basali cylindracea vel cuneata, 2-6 µm longa; cellula apicali globosa, clavata, integra, curvula, 10-12 x 8-10 µm. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, 18-20 x 8-10 µm. Setae myceliales numerosae, dispersae, rectae, simplices, acutae, ad 315 µm longae. Perithecia dispersa, verrucosa, ad 160 µm; sporae obovoidae, 4-septatae, constrictae, 36-40 x 14-16 µm.

Colonies hypophyllous, scattered, dense, velvety up to 10 mm in diameter, confluent. Hyphae substraight to undulating, branching opposite to irregular at wide angles, loosely reticulate, cells 24-30 x 6-8 µm. Capitate hyphopodia alternate, unilateral to 10% opposite, straight, spreading, antrorse to reflexed, 12-16 µm long; stalk cells cylindrical to cuneate, 2-6 µm long; head cells globose, entire, curved, 10-12 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 18-20 x 8-10 µm. Mycelial setae numerous, scattered, straight, simple, acute at the tip, up to 315 µm long. Perithecia scattered, verrucose, up to 160 µm; spores obovoidal, 4-septate, constricted, 36-40 x 14-16 µm.

Holotype: On leaves of Drypetes macrophylla (Bl.) Pax. & Hoffm. (Euphorbiaceae), Idukki, Feb. 18, 1983, V.B. Hosagoudar, HCIO 40521; MH 75834, Isotype.

Meliola hymenocardiae Hansf. can be compared with the present species (Hansf., 1961) but it differs in forming hypophyllous colonies, and in having 10% opposite and crowded capitate hypopodia and smaller setae. There is no record of the genus Meliola on this host genus.

33. **Meliola erycibis-paniculatae** Hosagoudar, sp. nov Fig.15.

Plagulae amphigenae, plerumque hypophyllae, saepe halonibus luteis cinctae, subdensae, ad 4 mm diam., confluentes. Hyphae mycelii subrectae, plerumque oppositae acuteque ramosae, cellulis 16-24 x 6-10 µm. Hyphopodia capitata densa, plerumque opposita, antrorsa, recta vel curvula, 20-26 µm longa; cellula basali cuneata, 6-10 µm longa; cellula apicali ovata vel obovata, integra, 12-18 x 10-12 µm. Hyphopodia mucronata et capitata commixta, opposita vel alternata, ampullacea, 16-22 x 8-10 µm. Setae myceliales dispersae vel etiam juxta perithecia, arcuatae, simplices, acutae vel obtusae ad apicem, ad 378 µm longae. Perithecia dispersa, verrucosa, ad 225 µm; sporae oblongae, 4-septatae, constrictae, 45-52 x 14-20 µm.

Colonies amphigenous, mostly hypophyllous, often show yellow haloes around the colonies, subdense, up to 4 mm in diameter, rarely confluent. Hyphae substraight, branching mostly opposite at acute angles, closely reticulate, cells 16-24 x 6-10 µm. Capitate hyphopodia closely arranged, mostly opposite, closely antrorse, straight to curved, 20-26 µm long; stalk cells cuneate, 6-10 µm long; head cells ovate to obovate, entire, 12-18 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 16-22 x 8-10 µm. Mycelial setae scattered to grouped around perithecia, arcuate, simple, acute to obtuse at the tip, up to 378 µm long. Perithecia scattered, verrucose, up to 225 µm; spores oblong, 4-septate, constricted, 45-52 x 14-20 µm.

Holotype: On leaves of Erycibe paniculata Roxb. (Convolvulaceae), Idukki, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40522; MH 73700, Isotype.

Two species of Meliola, namely Meliola erycibis Hansf. and M. erycibicola Sawada & Yaman. have been recorded on Erycibe rheedii Bl. and E. henryi Prain from Java and Taiwan (Sawada, 1959; Hansf., 1961). The new species differs from these in having alternate and opposite capitate hyphopodia, mucronate hyphopodia mixed with the capitate hyphopodia, smaller and arcuate mycelial setae and smaller ascospores.

34. **Meliola erythropalii** Hosagoudar, sp. nov. Fig. 16.

Plagulae amphigenae, plerumque epiphyllae, densae, velutinae, ad 4 mm diam., confluentes. Hyphae leniter undulatae, opposite vel irregulariter acuteque ramosae, laxe reticulatae, cellulis 12-32 x 5-8 µm. Hyphopodia capitata alternata vel unilateralia, recta, antrorsa vel patentia, 18-20 µm longa; cellula basali cylindracea vel cuneata, 4-6 µm longa; cellula apicali ovata, globosa, integra, 12-14 x 10-12 µm. Hyphopodia mucronata pauca, illis capitatis commixta, dispersa, alternata vel opposita, ampullacea, 14-20 x 8-10 µm. Setae myceliales dispersae, simplices, rectae, acutae, ad 315 µm longae. Perithecia dispersa, verrucosa, ad 180 µm; sporae oblongae, 4-septatae, leniter constrictae, 38-44 x 10-16 µm.

Colonies amphigenous, mostly epiphyllous, dense, velvety, up to 4 mm in diameter, confluent. Hyphae slightly undulating, branching opposite to irregular at acute angles, loosely reticulate, cells 12-32 x 5-8 µm. Capitate hyphopodia alternate to unilateral, straight, antrorse, spreading, 18-20 µm long; stalk cells cylindrical to cuneate, 4-6 µm long; head cells ovate, globose, entire, 12-14 x 10-12 µm. Mucronate hyphopodia few, mixed with capitate hyphopodia, alternate to opposite, ampulliform, 14-20 x 8-10 µm. Mycelial setae scattered, simple, straight, acute at the tip, up to 315 µm long. Perithecia scattered, verrucose, up to 180 µm; spores oblong, 4-septate, slightly constricted, 38-44 x 10-16 µm.

Holotype: On leaves of Erythropalum populifolium (Arn.) Mast. (Erythropalaceae), Idukki, Dec. 13, 1982, V.B. Hosagoudar, HCIO 40523; MH 75730, Isotype.

Earlier, Erythropalum was classified in the Olacaceae (Bentham & Hooker, 1862-1888), but, it is now placed in a monotypic separate family, the Erythropalaceae (Willis 1973, Santapau & Henry, 1973). The new species is close to M. anacolosae Hansf., on Anacolosa frutescens Bl. from Java (Hansf., 1961), but differs from it in having longer, straight, simple setae. There is no earlier record of meliolaceous fungi on this host genus; hence a new species is proposed.

35. **Meliola erthroxylifolii** Batista & Vital, Ann. IV Congr. Soc. Bot. Brazil, p. 105, 1953.

On leaves of Erythroxylum obtusifolium (Wight) Hook. f. (Erythroxylaceae), Idukki, Dec. 28, 1983, V.B. Hosagoudar, HCIO 40524; MH 80323.

This collection varies slightly from the description in having longer mycelial setae, smaller perithecia and slight variation in the ascospore size.

36. **Meliola gamellipoda** Doidge, Bothalia 1:80, 1920.

On leaves of Jasminum ozoricum L.(Oleaceae), Calvary Mount, Oct. 6, 1983, V.B. Hosagoudar, MH 78188; Oct. 12, 1982, V.B. Hosagoudar, MH 73645; Kanchiar forest, Feb. 23, 1983, V.B. Hosagoudar, MH 75004; Lakshmi Estate, Oct. 6, 1983, V.B. Hosagoudar, MH 78183.

37. **Meliola glochidii** Stev. & Rold. ex Hansf. var. **velutini** Hosagoudar, var. nov. Fig. 17.

Differt a M. glochidii Stev. & Rold. ex Hansf. var. glochidii hyphopodiis capitatis oppositis et alternatis, setis myceliorum longioribus.

Colonies amphigenous, dense, velvety, up to 6 mm in diameter, confluent. Hyphae straight to undulating, branching opposite to alternate at acute angles, loosely recticulate, cells 24-30 x 6-8 µm. Capitate hyphopodia opposite, about 30% alternate, straight, antrorse, 12-16 µm long; stalk cells cuneate, 4-6 µm long; head cells globose, versiform, entire, 8-12 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, 12-18 x 6-8 µm. Mycelial setae fairly numerous, scattered, simple, acute at the tip, up to 630 µm long. Perithecia scattered, up to 184 µm; spores ellipsoidal, 4-septate, constricted, 42-50 x 16-18 µm.

Holotype: On leaves of Glochidion velutinum Wight (Euphorbiaceae), Kanchiar forest, Dec. 29, 1983, V.B. Hosagoudar, HCIO 40526; MH 80343, Isotype.

Three species of Meliola are known on Glochidion, namely M. kansieriensia Hansf., M. glochidiicola Yamam, and M. glochidii Stev. & Rold. ex Hansf. (Hansf., 1961). The present material differs from M. kansieriensis Hansf. in having smaller capitate hyphopodia, setae, perithecia and ascospores. It differs from M. glochidiicola Yamam. in having opposite and alternate capitate hyphopodia and entire head cells on the capitate hyphopodia. It is closer to M. glochidii Stev. & Rold. ex Hansf. in having entire head cells of the capitate hyphopodia, but it differs from the var. glochidii in having opposite and alternate capitate hyphopodia, and longer mycelial setae.

38. **Meliola glochidiicola** Yamam., Trans. Nat. Hist. Soc. Formosa 31: 19,1941.

On leaves of Glochidion ellipticum Wight (Euphorbiaceae), Idukki, Kerala, April 11, 1982, V.B. Hosagoudar, HCIO 40527; MN 73629; Calvary Mount, Idukki, Kerala, Oct. 12, 1982, V.B. Hosagoudar, MH 73646; Dec. 11, 1982, V.B. Hosagoudar, MH 73687; Oct. 4, 1983, V.B. Hosagoudar, MH 78143.

The collections cited vary slightly from published descriptions (Hansf. 1961) in having smaller capitate hyphopodia, perithecia and longer mycelial setae.

39. **Meliola glycosmidis** Kapoor, Indian Phytopath. 20: 153, 1967.

On leaves of Glycosmis macrocarpa Wight (Rutaceae), Painavu, Feb. 19, 1983, V.B. Hosagoudar, HCIO 40528; MH 75850.

40. **Meliola gneti** Hansf., Reinwardtia 3: 85, 1954.

On leaves of Gnetum ula Brogn. (Gnetaceae), Idukki, Feb. 20, 1983, V.B. Hosagoudar, HCIO 40529; MH 75811; Feb. 25, 1983, V.B. Hosagoudar MH 75021; June 11, 1983, V.B. Hosagoudar MH 75071.

41. **Meliola groteana** H. Sydow & Sydow, Ann. Mycol. 11:402, 1913.

On leaves of Maesa indica (Roxb.) DC. (Myrsinaceae), Calvary Mount, Jan. 8, 1982, V.B. Hosagoudar, MH 72647; Idukki, April 19, 1982, V.B. Hosagoudar, HCIO 40530; MH 737919.

42. **Meliola holigarnae** Stev., Mem. Dept. Agric. India Bot. Ser. 15: 108, 1928.

On leaves of Holigarna grahamii (Wight) Kurz (Anacardiaceae), Kanchiar forest, Dec. 17, 1982, V.B. Hosagoudar, HCIO 40531; MH 75797. On leaves of H. ferruginea March., Idukki, June 10, 1983, V.B. Hosagoudar, MH 75066.

43. **Meliola hunteriae** Hosagoudar, sp. nov. Fig. 18.

Plagulae hypophyllae, densae, ad 5 mm diam., raro confluentes, maculae luteohalonatae, postremo foramenascentes. Hyphae subrectae vel leniter undulatae, alternatae vel oppositae acuteque ramosae, laxe reticulatae, cellulis 12-26 x 6-8 µm. Hyphopodia capitata alternata, recta vel curvula, antrorsa, 22-30 um longa; cellula basali cuneata, 6-10 µm longa; cellula apicalis late ovalis, integra vel irregulariter sublobata, 14-22 x 10-14 µm. Hyphopodia mucronata plerumque in hyphis distinctis evoluta, alternata, unilateralia vel raro opposita, ampullacea, 16-22 x 6-8 µm. Setae myceliales numerosae, dispersae et etiam juxta perithecia aggregatae, simplices, acutae, ad 522 µm longae. Perithecia dispersa, verrucosa, ad 76 µm; sporae oblongae, 4-septatae, constrictae, 38-42 x 14-20 µm.

Colonies hypophyllous, dense, up to 5 mm in diameter, often confluent, cause leaf spots and yellow haloes around the infected spots, corresponding upper surface of the leaf turned yellow and resulted in the shot holes. Hyphae substraight to slightly undulating, branching alternate to opposite at acute angles, loosely reticulate, cells 12-26 x 6-8 µm. Capitate hyphopodia alternate, straight to curved, antrorse, 22-30 µm long; stalk cells cuneate, 6-10 µm long;

head cells broadly ovate, entire to irregularly sublobate, 14-22 x 10-14 µm. Mucronate hyphopodia mostly borne on a separate mycelial branch, alternate, unilateral, rarely opposite, ampulliform, 16-22 x 6-8 µm. Mycelial setae numerous, scattered to grouped around perithecia, simple, acute at the tip, up to 522 µm long. Perithecia scattered, verrucose, up to 76 µm; spores oblong, 4-septate, constricted, 38-42 x 14-20 µm.
Holotype: On leaves of Hunteria corymbosa Roxb. var. roxburghiana Trin. (Apocyanaceae), Idukki, Dec. 28, 1983, V.B. Hosagoudar, HCIO 40532.

This species is distinct from the other Meliola species recorded on the members of the family Apocyanceae in producing a pathogenic effect on the host. There is no earlier report of a Meliola species on this host genus and the host is supposed to be endemic to peninsular India.

44. **Meliola indica** H. Sydow & P. Sydow, Ann. Mycol. 9: 382, 1911.

On leaves of Careya arborea Roxb. (Lecythidaceae), Idukki, Jan. 10, 1982, V.B. Hosagoudar, HCIO 40533; MH 72652; Vazhathope, Feb. 26, 1983, V.B. Hosagoudar, MH 75039; Idukki, Oct. 2, 1983, V.B. Hosagoudar, MH 78105, 78122; Oct. 8, 1983, V.B. Hosagoudar, MH 78911; Dec. 28, 1983, V.B. Hosagoudar, MH 80325.

45. **Meliola ixorae** Yates var. **macrospora** Hosagoudar, var. nov. Fig. 19.

Differt a M. ixorae Yates var. ixorae setis myceliorum longioribus et ascosporis magnioribus.

Colonies hypophyllous, thin, up to 10 mm in diameter. Hyphae tortuous, branching opposite to irregular at wide to acute angles, loosely reticulate, cells 28-32 x 6-10 µm. Capitate hyphopodia alternate to unilateral, distantly placed, spreading, antrorse, straight to curved, 22-34 µm long; stalk cells cuneate to cylindrical, 6-12 µm long; head cells ovate, angulor to slightly lobate, 14-20 x 12-16 µm. Mucronate hyphopodia borne on a separate mycelial branch, alternate, rarely opposite, ampulliform, 12-20 x 6-12 µm. Mycelial setae scattered, mostly grouped around perithecia, simple, acute to obtuse at the tip, up to 1035 um long. Peritheica scattered, verrucose, up to 170 µm; spores obovoidal to cylindrical, terminal cells broadly conoid, 42-48 x 12-14 µm.

Holotype: On leaves of Ixora elongata Heyne (Rubiaceae), Idukki, Feb. 18, 1983 V.B. Hosagoudar, HCIO 40534; MH 75841, Isotype. Paratype: On leaves of I. nigricans R. Br., Kakatode, Feb. 26, 1984, M. Ali, MH 80363.

Five species of Meliola have been recorded on Ixora. Kar & Maity (1972) recorded M. tawaoensis Hansf. on Ixora undulata Roxb. from West Bengal. The new variety differs in having hypophyllous colonies, with only alternate capitate hyphopodia and in having longer setae. It is very close to M. ixorae Yates but differs from the type variety in having longer mycelial setae and larger ascospores.

46. **Meliola jasminicola** P. Henn. var. **indica** Kapoor, Indian Phytopath. 20: 156, 1967.

On leaves of Jasminum rottlerianum Wall. (Oleaceae), Idukki, Dec. 13, 1982, V.B. Hosagoudar, MH 75862, HCIO 40535.

47. **Meliola ligustri** Hosagoudar, sp. nov. Fig. 20.

Plagulae amphigenae, subdensae, usque ad 4 mm diam. vel confluentes. Hyphae mycelii flexuosae, opposite vel irregulariter lateque ramosae, laxe reticulatae, cellulis 20-30 x 6-8 µm. Hyphopodia capitata alternata, patentia, antrorsa, recta vel curvula, 20-24 µm longa; cellula basali cylindracea vel cuneata, 6-8 µm longa; cellula apicali globosa, cylindracea, versiformis, angulosa, integra, 12-18 x 8-10 µm. Hyphopodia mucronata et capitata commixta, alternata vel opposita, ampullacea, 16-20 x 6-8 µm. Setae myceliales subnumerosae, dispersae, simplices, acutae vel obtusae ad apices, ad 270 µm longae. Perithecia dispersa, ad 160 µm; sporae obovoidae, 4-septatae, constrictae, 36-40 x 14-16 µm.

Colonies amphigenous, subdense, up to 4 mm in diameter, confluent. Hyphae flexuous, branching opposite to irregular at wide angles, loosely reticulate, cells 20-30 x 6-8 µm. Capitate hyphopodia alternate, spreading, antrorse, straight to curved, 20-24 µm long; stalk cells cylindrical to cuneate, 6-8 long; head cells globose, cylindrical, versiform, angulose, entire, 12-18 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, tip twisted and elongated, 16-20 x 6-8 µm. Mycelial setae fairly numerous, scattered, simple, acute to obtuse at the tip, up to 270 µm long. Perithecia scattered, verrucose, up to 160 µm; spores obovoidal, 4-septate, constricted, 36-40 x 14-16 µm.

Holotype: On leaves of Ligustrum walkeri Decne (Oleaceae), Lakshmi Estate, June 12, 1983, V.B. Hosagoudar, HCIO 40536; MH 75079, Isotype. Paratypes: Lakshmi Estate, Dec. 15, 1982, V.B. Hosagoudar, MH 75758, 75771; Puliyanmala, Feb. 23, 1984, M. Ali, MH 80370.

These collections cannot be assigned to any species of Meliola recorded on Oleaceae. Thite & Kulkarni (1973) recorded M. malabarensis Hansf. on Ligustrum neligherrense Wight var. obovata Clerke from Maharashtra. The present species differs from it in having longer capitate hyphopodia, shorter mycelial setae, and larger ascospores.

48. **Meliola linderae** Yaman., Trans. Nat. Soc. Formosa 31:20, 1941.

On leaves of Actinodaphne hookeri Meissen. (Lauraceae), Meenumutty, Oct. 10, 1982, V.B. Hosagoudar, HCIO 40537; MH 73608; Idukki, Dec. 11, 1982, V.B. Hosagoudar, MH 73686; Dec. 23, 1983, V.B. Hosagoudar, MH 73038.

49. **Meliola linociericola** Hansf., Proc. Linn. Soc. London 160: 128, 1948.

On leaves of Chionanthus malabarica (Wall, ex DC.) Bedd. (Linociera malabarica Wall.) (Oleaceae), Vazhathope, Jan. 7, 1982, V.B. Hosagoudar, MH 71584; Lakshmi Estate, Dec. 25, 1983, V.B. Hosagoudar, MH 79075, 79085, 79086; Idukki, June 10, 1983, V.B. Hosagoudar, MH 75052; Lakshmi Estate, June 12, 1983, V.B. Hosagoudar, MH 75090; Calvary Mount, Oct. 5, 19832, V.B. Hosagoudar, MH 78168.

50. **Meliola litseae** H. Sydow & P. Sydow var. **floribundae** Hosagoudar, var. nov. Fig. 21.

Differt a M. litseae H. Sydow & P. Sydow var. litseae hyphopodiis capitatis oppositis (5%), hyphopodiis mucronatis in hyphis distinctis evolutis et setis myceliis longioribus.

Colonies hypophyllous, subdense, velvety, up to 12 mm in diameter, confluent. Hyphae tortuous to crooked, branching opposite to irregular at wide angles, loosely reticulate, cells 36 - 42 x 6-10 µm. Capitate hyphopodia alternate, unilateral, 5% opposite, antrorse, spreading, straight to curved, 26-34 µm long; stalk cells cylindrical to cuneate, 8-12 µm long; head cells ovate to globose, truncate, slightly angulose to sublobate, straight to curved, 16-24 x 14-18 µm. Mucronate hyphopodia borne on a separate mycelial branch, alternate to opposite, ampulliform, 20-26 x 8-10 µm. Mycelial setae fairly numerous, grouped around perithecia, simple, acute at the tip, up to 1089 µm long. Perithecia scattered to grouped, up to 342 µm; spores ellipsoidal, 4-septate, 46-58 x 16-20 µm.

Holotype: On leaves of Litsea floribunda (Bl.) Gamble (Lauraceae), Lakshmi Estate, June 12, 1983, V.B. Hosagoudar, HCIO 40538; MH 75086, Isotype. Paratype: Kanchiar forest, Oct. 4, 1982, V.B. Hosagoudar, MH 73670.

The new variety differs from the type variety in having 5% opposite capitate hyphopodia, mucronate hyphopodia borne on a separate mycelial branch and having longer mycelial setae.

51. **Meliola litseae** H. Sydow & P. Sydow var. **insignis** Hosagoudar, var. nov. Fig. 22.

Differt a M. litseae H. Sydow & P. Sydow var. litseae plagulis hypophyllis, tenuibus, myceliis anfractis, peritheciis et ascosporis magnioribus.

Colonies hypophyllous, thin, up to 10 mm in diameter, confluent. Hyphae tortuous to crooked, branching alternate to irregular at acute angles, loosely reticulate, cells 18-22 x 6-8 µm. Capitate hyphopodia alternate to unilateral, straight to curved, antrorse, spreading, 14-20 µm long; stalk cells cuneate to cylindrical, 6-8 µm long; head cells ovate, clavate, globose, slightly angular, entire, 10-12 µm. Mucronate hyphopodia few, mixed with capitate hyphopodia, alternate, ampulliform, 16-22 x 8-10 µm. Mycelial setae fairly numerous, scattered, simple, acute to obtuse at the tip, up to 927 µm long. Perithecia scattered, verrucose, up to 200 um; spores obovoidal, 4-septate, constricted, 42-50 x 14-18 µm.

Holotype: On leaves of Litsea insignis Gamble (Lauraceae), Idukki, June 10, 1983, V.B. Hosagoudar, HCIO 40539; MH 75757, Isotype.

The new variety differs from the type variety in having hypophyllous, thin colonies, crooked mycelia, and larger perithecia and ascospores.

52. **Meliola litseae** H. Sydow & P. Sydow var. **keralense** Hosagoudar, var. nov. Fig. 23.

Differt a M. litseae H. Sydow & P. Sydow var. litseae plagulis epiphyllis, hyphopodiis capitatis parvioribus, setis myceliorum brevioribus et acutis, peritheciis myceliis exhyphopodiatis insidentibus et ascosporis parvioribus.

Colonies epiphyllous, subdense, up to 3 mm in diameter, rarely confluent. Hyphae substraight, branching opposite at wide angles, loosely reticulate, cells 14-20 x 8-10 µm. Capitate hyphopodia alternate, antrorse, 26-28 µm long; stalk cells cuneate, 6-8 µm long; head cells ovate, versiform, entire, 18-20 x 12-14 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, 18-26 x 8-10 µm. Mycelial setae few, mostly grouped around perithecia, simple, acute, up to 578 um long. Perithecia mostly scattered, seated on exhyphopodiate hyphae, up to 186 µm; spores obovoidal, 4-septate, slightly constricted, 36-38 x 18-20 µm.

Holotype: On leaves of Litsea stocksii Hook. f. var. glabrescense Hook. f. (Lauraceae), Idukki, Oct. 3, 1983, V.B. Hosagoudar, HCIO 40540; MH 78124, Isotype.

The new variety differs from the type variety in having epiphyllous colonies, smaller capitate hyphopodia, shorter and acute mycelial setae, perithecia seated on the exhyphopodiate mycelia and smaller ascospores.

53. **Meliola litseae** H. Sydow & P. Sydow var. **rotundipoda** Hansf., Reinwardtia 3:88, 1954.

On leaves of Litsea coriacea (Heyne ex Meissn.) Hook. f. (Lauraceae), near Painavu, Jan. 10, 1982, V.B. Hosagoudar,, HCIO 40541; MH 72639; Painavu, April 18, 1982, V.B. Hosagoudar, MH 72686; Dec. 13, 1982, V.B. Hosagoudar, MH 75740.

The collections cited vary slightly from published descriptions in having larger capitate hyphopodia, presence of few mycelial setae and larger ascopores.

54. **Meliola luvungae** Hosagoudar, sp. nov. Fig. 24.

Plagulae hypophyllae, densae, velutinae, ad 6 mm diam., confluentes. Hyphae rectae, plerumque opposite, raro alternate, acuteque ramosae, laxe reticulatae, cellulis 12-14 x 6-8 µm. Hyphopodia capitata alternata, leniter curvula, subantrorsa vel antrorsa, 16-20 µm longa; cellula basali cuneata, 4-6 µm longa; cellula apicalis ovata vel cylindracea, integra, 10-14 x 8-10 µm. Hyphopodia mucronata et capitata commixta, alternata vel opposita, ampullacea, 16-20 x 6-8 µm. Setae myceliales dispersae, rectae, simplices, acutae, ad 351 µm longae. Perithecia dispersa, verrucosa, ad 166 µm; sporae obovoidae, 4-septatae, constrictae, 40-42 x 14-18 µm.

Colonies hypophyllous, dense, velvety, up to 6 mm in diameter, confluent. Hyphae straight, branching mostly opposite and rarely alternate at acute angles, loosely reticulate, cells 12-14 x 6-8 µm. Capitate hyphopodia alternate, straight to slightly curved, subantrorse to antrorse, 16-20 µm long; stalk cells cuneate, 4-6 µm long; head cells ovate to cylindrical, entire, 10-14 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 16-20 x 6-8 µm. Mycelial setae scattered, straight, simple, acute at the tip, up to 351 µm long. Perithecia scattered, verrucose, up to 166 µm; spores obovoidal, 4-septate, constricted, 40-42 x 14-18 µm.

Holotype: On leaves of Luvunga elutherandra Dalz. (Rutaceae), Idukki, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40542; MH 75705, Isotype. Paratype: Oct. 2, 1983, V.B. Hosagoudar, MH 78108.

The new species differs from other Meliola species on Rutaceae in all of the principal morphological characters (Hansf., 1961). Further, there is no record of the genus Meliola on Luvunga.

55. **Meliola machili** Yamam., Trans. Nat. Hist. Soc. Formosa 31:23, 1941.

On leaves of Persea macrantha (Nees) Kosterm. (Machilus macrantha Nees) (Lauraceae), Idukki, Jan. 12, 1982, V.B. Hosagoudar, HCIO 40543; MH 72681; April 19, 1982, V.B. Hosagoudar, MH 73646, 73711; Dec. 15, 1982, V.B. Hosagoudar, MH 75764; Lakshmi Estate, June 12, 1983, V.B. Hosagoudar, MH 75092, 75094; Pooyankutty, June 16, 1983, V.B. Hosagoudar, MH 79021; Idukki, Oct. 8, 1983, V.B. Hosagoudar, MH 78134; Dec. 28, 1983, V.B. Hosagoudar, MH 80320; Calvary Mount, February 24, 1984, M. Ali, MH 80371; Idukki, Oct. 25, 1984 A. Diraviadoss, MH 82612.

The collections cited vary slightly from the description in forming hypophyllous colonies, smaller setae, and smaller ascospores.

56. **Meliola malabarensis** Hansf., Proc. Linn. Soc. London 157: 187, 1946.

On leaves of Olea dioica Roxb. (Oleaceae), Idukki, Jan. 10, 1982, V.B. Hosagoudar, HCIO 40544; MH 72646.

The collection cited varies from the description in having longer capitate hyphopodia and absence of 5% opposite capitate hyphopodia.

57. **Meliola malacotricha** Speg. var. **major** Beeli, Bull. Jard. Bot. Bruxelles 7:89, 1920.

On leaves of Argyeria hookeri Clark (Convolvulaceae), Vazhathope, Jan. 7, 1982, V.B. Hosagoudar, HCIO 40545; MH 71582. On leaves of Merremia umbellata (L.) Hall. (Convolvulaceae), Idukki, Oct. 3, 1983, V.B. Hosagoudar, MH 78125.

58. **Meliola mangiferae** Earle, Bull. New York Bot. Gard. 3:307, 1905.

On leaves of Mangifera indica L. (Anacardiaceae), Panamkutty, October 15, 1982, V.B. Hosagoudar, HCIO 40546; MH 73677; Dec. 18, 1982, V.B. Hosagoudar, MH 75814; Vazhathope, Feb. 26, 1983, V.B. Hosagoudar, MH 75036; Lakshmi Estate, October 6, 1983, V.B. Hosagoudar, MH 78184.

59. **Meliola memecyli** H. Sydow & P. Sydow, Ann. Mycol. 12: 198, 1914.

On leaves of Memecylon depressum Benth. (Melastomataceae), Feb. 18, 1983, V.B. Hosagoudar HCIO 40547, MH 75833, 75834, 75863; Meenuutty, Dec. 22, 1983, V.B. Hosagoudar,MH 78984.

60. **Meliola mucunae** Hansf. var. **hirsutae** Hosagoudar, var. nov. Fig. 25.

Differt a M. mucunae Hansf. var. mucunae plagulis epiphyllis, hyphopodiis 40% oppositis et setis myceliorum longioribus.

Colonies epiphyllous, thin, up to 3 mm in diameter, confluent. Hyphae undulating, branching opposite to irregular at acute angles, loosely to closely reticulate, cells 16-34 x 6-8 µm. Capitate hyphopodia alternate and about 40% opposite, straight, antrorse, spreading , 14-20 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells globose, entire, 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, scattered, opposite to alternate, ampulliform, 16-20 x 8-10 µm. Mycelial setae few, grouped around perithecia , straight to curved, simple, acute at the tip, up to 324 µm long. Perithecia scattered, verrucose, up to 176 µm; spores ellipsoidal, 4-septate, constricted, 30-36 x 12-14 µm.

Holotype: On leaves of Mucuna hirsuta Wight & Arn. (Papilionaceae), Idukki, Oct. 8, 1983, V.B. Hosagoudar HCIO 40548; MH 78902, Isotype. Paratype; December 23, 1983, V.B. Hosagoudar, MH 79034; Oct. 25, 1984, A. Diraviadoss, MH 82607.

Two species of the genus Meliola, namely M. mucunae-acuminatae Hansf. and M. mucunae Hansf., have been recorded on Mucuna from Java and Sierra Leone (Hansford, 1961). The new variety is closer to M. mucuna Hansf., in that it has alternate and opposite capitate hyphopodia and the mucronate hyphopodia are mixed with the capitate hyphopodia. However, the new variety differs from the var. macunae in having only epiphyllous colonies, 40% opposite capitate hyphopodia and longer mycelial setae.

61. **Meliola neolitseae** Yamam., Trans. Nat. Hist. Soc. Formosa 31: 24, 1941.

On leaves of Neolitsea zeylanica Merr. (Lauraceae), Lakshmi Estate Oct. 6, 1983, V.B. Hosagoudar, HCIO 40549; MH 78190, Sabarimalai Oct. 11, 1983. V.B. Hosagoudar, MH 78941; Lakshmi Estate, Dec. 15, 1985, A. Diraviadoss, MH 75760.

In the present collections, the mycelial setae are simple and the capitate hyphopodia are alternate only.

62. **Meliola nephelii** Sacc. var. singalensis Hansf., Sydowia 10: 80, 1957.

On leaves of Allophyllous serrulatus Redlk (Sapindaceae), Idukki, Oct. 10, 1982, V.B. Hosagoudar, HCIO 40550; MH 73621; Feb. 18, 1983, V.B. Hosagoudar, MH 75843; Dec. 23, 1983, V.B. Hosagoudar MH 79043; Feb. 24, M. Ali, MH 80367.

63. **Meliola nilgirianthii** Hosagoudar, sp. nov. Fig. 26.

Plagulae hypophyllae, densae, ad 2 mm diam., raro confluentes. Hyphae mycelii subrectae vel undulatae, plerumque opposite acuteque ramosae, cellulis 16-18 x 6-8 µm. Hyphopodia capitata alternata vel unilateralia, recta vel curvula, antrorsa vel patentia, 22-30 µm longa, cellula basali cylindracea vel cuneata, 8-12 µm longa; cellula apicali ovata, globosa, leniter angulosa, integra, 14-18 x 10-16 µm. Hyphopodia mucronata et capitata commixta, alternata vel opposita, ampullacea, 14-22 x 6-8 µm. Setae myceliales paucae, dispersae vel etiam juxta perithecia aggregatae, simplices, curvulae, acutae vel obtusae ad apicem, ad 270 µm longae. Perithecia aggregata, verrucosa, ad 180 µm; sporae obovoidae, 4-septatae, constrictae, 30-38 x 10-12 µm.

Colonies hypophyllous, dense, up to 2 mm in diam., rarely confluent. Hyphae substraight to undulating, branching mostly opposite at acute angles, loosely reticulate, cells 16-18 x 6-8 µm. Capitate hyphopodia alternate to unilateral, straight to curved, antrorse to spreading, 22-30 µm long; stalk cells cylindrical to cuneate, 8-12 µm long; head cells ovate, globose, slightly angular, entire, 14-18 x 10-16 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 14-22 x 6-8 µm. Mycelial setae few, scattered to grouped around perithecia, curved, acute to obtuse to weavy at the apex, up to 270 µm long. Perithecia aggregated, verrucose, up to 180 µm; spores obovoida, 4-septate, constricted, 30-38 x 10-12 µm.

Holotype: On leaves of Nilgirianthus heyneanus (Nees) Bremek. (Strobilanthes heyneanus Nees; S. rugosus Wight) (Acanthaceae), Lakshmi Estate, Dec. 25, 1983, V.B. Hosagoudar, HCIO 40551; MH 79087, Isotype. Paratype: Dec. 21, 1983, V.B. Hosagoudar, MH 78964.

This species can be compared with M. cladacantha Ciff. (Hansford, 1961), but differs from it in forming hypophyllous and dense colonies, larger petithecia and smaller ascospores. There is no species of Meliola recorded on this host.

64. **Meliola nothopegiae** Hansf., Sydowia 10: 80, 1957.

On leaves of Nothopegia beddomei Gamble (Anacardiaceae), Kanchiar forest, Dec. 12, 1982, V.B. Hosagoudar, MH 75765; Dec. 29. 1983, V.B. Hosagoudar, MH 80339.

65. **Meliola otonephelii** Hosagoudar, sp. nov. Fig. 27.

Plagulae amphigenae, atrae, plerumque epiphyllae, subdensae vel densae, dispersae, ad 4 mm diam. Hyphae mycelii brunneae, rectae vel subrectae, plerumque opposite lateque ramosae, laxe reticulatae, cellulis 12-18 x 6-8 µm. Hyphopodia capitata alernatea vel ad 40% opposita, recta vel curvula, antrorsa vel reflexa, 16-22 µm longa; cellula basali cylindracea vel cuneata, 4-8 µm longa; cellula apicali plerumque conoidea, cylindracea, versiformis, piriformis, recta vel curvula, integra, 12-14 x 6-8 µm. Hyphopodia mucronata et capitata commixta, opposita vel alternata, ampullacea, 16-26 x 8-10 µm. Setae myceliales paucae, plerumque juxta perithecia aggregatae, atrae, simplices, rectae, obtusae vel dentatae, ad 225 µm longae. Perithecia pauca, verrucosa, ad 170 µm; sporae brunneae, obovoidae vel cylindraceae, 4-septatae, leniter constrictae, 44-48 x 16-18 µm.

Colonies amphigenous, mostly epiphyllous, subdense to dense, scattered, up to 4 mm in diameter. Hyphae straight to substraight, branching mostly opposite at wide angles, loosely reticulate, cells 12-18 x 6-8 µm. Capitate hyphopodia alternate to about 40% opposite, spreading, straight to curved, antrorse to reflexed, 16-22 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells mostly conoid, cylindrical, versiform, pyriform, straight to curved, entire, 12-14 x 6-8 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 16-26 x 8-10 µm. Mycelial setae few, grouped around perithecia, straight, simple, obtuse to variously dentate at the tip, up to 225 µm long. Perithecia few, verrucose, up to 170 µm; spores obovoidal to cylindrical, 4-septate, slightly constricted, 44-48 x 16-18 µm.

Holotype: On leaves of *Otonephelium stipulaceum* (Bedd.) Radlk. (=*Nephelium stipulaceum* Bedd.) (Sapindaceae), Idukki, Dec. 23, 1983, V.B. Hosagoudar, HCIO 40552; MH 79033, Isotype. Paratypes: Feb. 18, 1983, V.B. Hosagoudar, MH 75845; Dec. 21, 1983, V.B. Hosagoudar, MH 78957; Oct. 10, 1982, V.B. Hosagoudar, MH 73605.

The *Meliola* species with head cells more or less conoid or cylindro-clavate recorded on the members of the family Sapindaceae have been treated as varieties of *M. capensis* (K. & C.) Theiss. (Hansf., 1961). The new species differs in all the principal morphological characters from the recorded species. Further, there is no record of any meliolaceous fungus on this host.

66. **Meliola pogostemonis** Hansf., Sydowia 10:83, 1957.
On leaves of *Pogostemon pubescens* Benth. (Labiatae), Calvary Mount, Idukki, Jan. 8, 1982, V.B. Hosagoudar, HCIO 40553; MH 72615; Lakshmi Estate, Dec. 25, 1983; V.B. Hosagoudar MH 79096.

67. **Meliola premnicola** Hosagoudar, sp. nov. Fig. 28.

Plagulae epiphyllae, subdensae, usque ad 5 mm diam., raro confluentes. Hyphae mycelii subrectae vel flexuosae, brunneae, opposite lateque ramosae, densae reticulatae, cellulis 26-30 x 8-10 µm. Hyphopodia capitata alternata vel usque ad 30% opposita, antrorsa, 16-20 µm longa; cellula basali cuneata, 4-6 µm longa; cellula apicali globosa, ovata, integra, 12-14 x 10-12 µm. Hyphopodia mucronata et capitata commixta, opposita vel alternata, ampullacea, 18-22 x 8-10 µm. Setae myceliales dispersae, plerumque juxta perithecia aggregatae, rectae, simplices, obtusae vel dentatae, ad 720 µm longae. Perithecia dispersa, verrucosa, ad 170 µm; sporae ellipsoidae, 4-septatae, constrictae, 42-48 x 14-16 µm.

Colonies epiphyllous, subdense, up to 5 mm in diameter, rarely confluent. Hyphae substraight to flexuous, branching opposite at acute angles, closely reticulate, cells 26-30 x 8-10 µm. Capitate hyphopodia alternate, about 30% opposite, antrorse, 16-20 µm long; stalk cells cuneate, 4-6 µm long; head cells globose, ovate, entire, 12-14 x 10-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, neck elongated and twisted, 18-22 x 8-10 µm. Mycelial setae grouped around perithecia, straight, simple, variously dentate at the apex, up to 720 µm long. Perithecia scattered, verrucose, up to 170 µm; spores ellipsoidal, 4-septate, deeply constricted, 42-48 x 14-16 µm.

Holotype: On leaves of Premna glaberrima Wight (Verbenaceae), Idukki, Feb. 18, 1983, V.B. Hosagoudar, HCIO 40554; MH 75837, Isotype.

Three species of Meliola, M. premnae Hansf., M. cookeana Speg. and M. callicarpae Sydow & Sydow have been recorded on Premna. The new species differs from M. premnae Hansf. in lacking the crooked mycelial setae, from M. cookeana Speg. in having substraight to flexuous mycelia and 30% opposite capitate hyphopodia, and from M. callicarpae H. Sydow & Sydow in having longer capitate hyphopodia, longer and dentate mycelial setae, larger perithecia and ascospores.

68. **Meliola psychotriae** Earle, Bull. New York Bot. Gard. 3:308, 1905.

On leaves of Pavetta indica L. (Rubiaceae), Idukki, Dec. 11, 1982, V.B. Hosagoudar, MH 75721; Lakshmi Estate, Dec. 15, 1982, V.B. Hosagoudar, MH 75767; Oct. 6, 1983, V.B. Hosagoudar, MH 78969; Lakshmi Estate, Dec. 25, 1983, V.B. Hosagoudar, MH 79097.

69. **Meliola quadrispina** Racib., Parasit. Algen und Pilze Java's 3:33, 1900.

On leaves of Argyeria elliptica (Roth) Choisy (Convolvulaceae), Idukki, Oct. 11, 1982, V.B. Hosagoudar, HCIO 40555; MH 73622. On leaves of A. hookeri Clarke, Idukki, Oct. 6, 1983, V.B. Hosagoudar, MH 78189.

70. **Meliola ramosii** H. Sydow & P. Sydow, Ann. Mycol. 12:552, 1914.

On leaves of Homonoia riparia Lour. (Euphorbiaceae), Panamkutty, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40556; MH 75810; Pooyankutty, June 16, 1983, V.B. Hosagoudar, MH 79020; Panamkutty, Oct. 6, 1984, A. Diraviadoss, MH 82609.

71. **Meliola rickiana** Hansf. var. **zanthoxyli** Hosagoudar, var. nov. Fig. 29.

Differt a M. rickiana Hansf. var. rickiana setis myceliorum rectis et longioribus, peritheciis et ascosporis parvioribus.

Colonies amphigenous, mostly hypophyllous, subdense, up to 4 mm in diameter, confluent. Hyphae mostly straight, branching mostly opposite, rarely alternate at acute angles, closely reticulate, cells 12-22 x 8-10 µm. Capitate hyphopodia alternate, about 10% opposite, straight to curved, antrorse to spreading, 20-22 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells ovate, versiform; often angular, straight to curved, entire, 14-16 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, mostly ampulliform, 18-20 x 8-10 µm. Mycelial setae numerous, straight, acute to 2-3 dentate at the apex, up to 810 µm long. Perithecia mostly grouped, verrucose, up to 200 µm; spores obovoidal, 4-septate, slightly constricted, 36-40 x 16-18 µm.

Holotype: On leaves of Zanthoxylum ovata Wight (Rutaceae), Lakshmi Estate, Aug. 12, 1983, V.B. Hosagoudar, HCIO 40557; MH 75082, Isotype. Paratype: Lakshmi Estate, Oct. 6, 1983, V.B. Hosagoudar, MH 78181, 79091.

Kapoor (1967) recorded M. zanthoxyli Hansf. on Zanthoxylum ovalifolium Wight from Karnataka. The new variety differs from M. zanthoxyli in having alternate and opposite, as well as smaller capitate hyphopodia, entire head cells of the capitate hyphopodia, smaller and straight mycelial setae and smaller ascospores.

Zanthoxylum ovata Wight is synonymous with Fagara ovata. Nine species of Meliola have been recorded on these hosts. Of these, M. rickiana Hansf. is closest to the present collection, in having alternate and opposite capitate hyphopodia, acute to dentate mycelial setae. The new variety differs from var. rickiana in having straight and larger mycelial setae, smaller perithecia and ascospores.

72. **Meliola salleana** Hansf. var. **smilacis** Hosagoudar, var. nov. Fig. 30.

Differt a M. salleana Hansf. var. salleana hyphis rectis, capitibus hyphopodiorum integris, hyphopodiis mucronatis et hyphopodiis capitatis mixtis, ascosporis et setis myceliorum magnioribus. A M. gregoriana Stev. var. confusa Cif. hyphis rectis, capitatis hyphopodiorum capitatorum ovatis vel integris, setis parvioribus et ascosporis magnieribus differt.

Colonies amphigenous, mostly epiphyllous, subdense, up to 4 mm in diameter, rarely confluent. Hyphae straight, branching opposite at acute angles, loosely to closely reticulate, cells 10-30 x 6-9 µm. Capitate hyphopodia alternate, straight, antrorse, 18-32 µm long; stalk cells cuneate, 5-14 µm long; head cells ovate, bluntly pointed, entire, 12-16 x 8-12 µm. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 18-28 x 8-12 µm. Mycelial setae mostly grouped around perithecia, straight, simple, acute at the apex, up to 855 um long. Perithecia scattered, verrucose, up to 198 µm; spores obovoidal, 4-septate, constricted, 42-50 x 18-20 µm.

Holotype: On leaves of Smilax zeylanica L. (Smilacaceae), Idukki, Jan. 11, 1982, V.B. Hosagoudar, HCIO 40558; MH 72660, Isotype. Paratypes: Reservoir side of Calvary Mount, Dec. 24, 1983, V.B. Hosagoudar, MH 79066; Idukki, Feb. 23, 1984, V.B. Hosagoudar, MH 80365.

Five taxa of the genus Meliola have been recorded on Smilax (Hansf., 1961), of which M. gregoriana Stev. var. confusa Cif. and M. salleana Hansf. have alternate capitate hyphopodia. The new variety differs from M. gregoriana var. confusa in having straight hyphae, entire head cells of the capitate hyphopodia, smaller setae and larger ascospores. The new variety differs from the var. salleana in having ovate and entire head cells of the capitate hyphopodia, mucronate hyphopodia mixed with capitate hyphopodia, larger ascospores and mycelial setae.

73. **Meliola sarcostigmae** Hosagoudar, sp. nov. Fig. 31.

Plagulae hypophyllae, densae, velutinae, usque ad 5 mm diam., raro confluentes. Hyphae mycelii subrectae vel undulatae, brunneae, plerumque opposite lateque ramosae, densae reticulatae, cellulis 24-32 x 6-10 µm. Hyphopodia capitata alternata vel 10% opposita, recta vel curvula, patentia, antrorsa, 14-24 µm longa; cellula basali cylindracea vel cuneata, 4-10 µm longa; cellula apicali ovata, globosa, integra, 10-14 x 8-10 µm. Hyphopodia mucronata et capitata commixta, opposita vel alternata, ampullacea, 22-26 x 6-10 µm. Setae myceliales numerosae, dispersae, rectae, simplices, obtusae vel acutae, ad 468 µm longae. Perithecia dispersa, verucosa, ad 170 µm; sporae obovoidae, 4-septatae, constrictae, 38-44 x 14-16 µm.

Colonies hypophyllous, dense, velvety, up to 5 mm in diameter, rarely confluent. Hyphae substraight to undulating, branching mostly opposite at wide angles, closely reticulate, cells 24-32 x 6-10 µm. Capitate hyphopodia alternate, about 10% opposite, straight to curved, antrorse, spreading, 14-24 µm long; stalk cells cylindrical to cuneate, 4-10 µm long; head cells ovate, globose, entire, 10-14 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 22-26 x 6-10 µm. Mycelial setae numerous, scattered, straight, simple, acute to obtuse at the tip, up to 468 µm long. Perithecia scattered, surface cells projecting, up to 170 µm; spores obovoid, 4-septate, constricted, 38-44 x 14-16 µm.

Holotype: On leaves of Sarcostigma kleinii Wight & Arn. (Icacinaceae), Idukki, Kerala, Feb. 18, 1983, V.B. Hosagoudar, HCIO 40561; MH 75835, Isotype.

Eight species of Meliola have been recorded on members of the Icacinaceae but none is close to new species (Hansf., 1961). Further, there is no record of Meliola on Sarcostigma.

74. **Meliola scleropyri** Hosagoudar, sp. nov. Fig. 32.

Plagulae amphigenae, plerumque hypophyllae, densae, velutinae, ad 4 mm diam, confluentes. Hyphae subrectae vel undulatae, oppositae vel irregulariter acuteque ramosae, laxe reticulatae, cellulis plerumque 10-14 x 6-8 µm. Hypopodia capitata alternata vel unilateralia, subantrorsa vel antrorsa, 22-28 µm longa; cellula basali plerumque cuneata, 8-13 µm longa; cellula apicali ovata vel piriformis, integra, 13-18 x 12-14 µm. Hyphopodia mucronata pauca, illis capitatis commixta, opposita vel alternata, ampullacea, 18-20 x 8-10 µm. Setae myceliales numerosae, etiam juxta perithecia aggregatae, rectae, simplices, acutae vel obtusae, ad 280 µm longae. Perithecia dispersa vel aggregata, verrucosa, ad 153 µm; sporae obovatae, 4-septatae, constrictae, 32-36 x 11-12 µm.

Colonies amphigenous, mostly hypophyllous, dense, velvety, up to 4 mm in diameter, confluent. Hyphae substraight to slightly undulating, branching opposite to irregular at acute angles, loosely reticulate, cells 10-14 x 6-8 µm. Capitate hyphopodia alternate to unilateral, subantrorse to antrorse, 22-28 µm long; stalk cells mostly cuneate, 8-13 µm long; head cells ovate, pyriform, entire, 13-18 x 12-14 µm. Mucronate hyphopodia few, mixed with capitate hyphopodia, alternate to opposite, ampulliform, 18-20 x 8-10 µm. Mycelial setae numerous, grouped around perithecia, straight, simple, acute to obtuse at the tip, up to 280 µm long. Perithecia scattered to grouped, verrucose, up to 153 µm; spores obovate, 4-septate, constricted, 32-36 x 11-12 µm.

Holotype: On leaves of Scleropyrum pentandrum (Dennst.) Mabberley (S. wallichianum (Wight & Arn.) Arn.) (Santalaceae), Calvary Mount, April 25, 1982, V.S. Raju, HCIO 40563; MH 73771, Isotype. Paratypes: Calvary Mount, Feb. 21, 1983, V.B. Hosagoudar, MH 75580; Idukki, Feb. 25, 1983, V.B. Hosagoudar, MH 75024; Feb. 26, 1984, M. Ali, MH 80375.

Five species and a variety of the genus Meliola have been recorded on the members of the family Santalaceae (Hansf., 1961). None of them is comparable to the present species. Further, there is no record of any meliolaceous fungi on the host genus Scleropyrum.

75. **Meliola semecarpicola** Hansf., Sydowia 11: 58, 1958

On leaves of Semecarpus travancorica Bedd., (Anacardiaceae), Idukki, Dec. 19, 1982, A. Diraviadoss, HCIO 40562; MH 75821.

The present collection varies slightly in having dentate setae and larger ascospores. However, the fungus did not show the pathogenic effect on the host noted by Hansford (1961).

76. **Meliola stemonuri** Hosagoudar, sp. nov. Fig. 33.

Plagulae amphigenae, caulicolae, densae, velutinae, ad 3 mm diam., confluentes. Hyphae rectae vel subrectae, alternatae vel oppositae acuteque ramosae, densae reticulatae, cellulis 22-28 x 10-14 µm. Hyphopodia capitata alternata vel unilateralia, recta vel curvula, antrorsa vel reflexa, 24-32 µm longa; cellula basali cylindracea vel cuneata, 8-16 µm longa; cellula apicali globosa, ovata, integra, 14-16 µm. Hyphopodia mucronata et capitata commixta, dispersa, opposita vel alternata, ampullacea, 22-30 x 8-10 µm. Setae myceliales dispersae et etiam juxta perithecia aggregatae, simplices, curvulae, acutae vel obtusae, ad 648 µm longae. Perithecia dispersa, verrucosa, ad 198 µm; sporae obovoidae, 4-septatae, constrictae, 54-60 x 16-24 µm.

Colonies amphigenous, caulicoulous, dense, velvety, up to 3 mm in diameter, confluent. Hyphae straight to substraight, branching alternate to opposite at acute angles, closely reticulatae, cells 22-28 x 10-14 µm. Capitate hyphopodia alternate to unilateral, straight to curved, antrorse to reflexed, 24-32 µm long; stalk cells cylindrical to cuneate, 8-16 long; head cells globose, ovate, entire, 14-16 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 22-30 x 8-10 µm. Mycelial setae scattered and grouped around perithecia, simple, curved, acute to obtuse at the tip, up to 648 µm long. Perithecia scattered, verrucose, up to 198 µm; spores obovoidal, 4-septate, constricted, 54-60 x 16-24 µm.

Holotype: On leaves, petioles and stems of Stemonurus tetrandrus (Wall. ex Roxb.) Alston (Gomphandra tetrandra Wall. ex Roxb.) (Icacinaceae), Idukki, Dec. 21, 1983, V.B. Hosagoudar, HCIO 40560; MH 78962. Paratypes: Idukki, Oct. 9, 1982, V.B. Hosagoudar, MH 75830, Isotype. Lakshmi Estate, Dec. 12, 1982, V.B. Hosagoudar, MH 75769; Dec. 23, 1983; V.B. Hosagoudar, MH 79040; Dec. 28, 1983, V.B. Hosagoudar, MH 80319; Dec. 38, 1983, V.B. Hosagoudar, MH 80331.

Eight species of Meliola have been recorded on the members of the family Icacinaceae (Hansf., 1961). Of these, only M. citronellae Hansf., recorded on Citronella sp. from New South Wales, is comparable with the present species. M. stemonuri differs in having shorter capitate hyphopodia, smaller perithecia, larger mycelial setae and ascospores. Further, there is no record of the genus Meliola on this host.

77. **Meliola symplocicola** Yamam., Trans. Nat. Hist. Soc. Formosa 31: 57; 1941.

On leaves of Symplocos cochinchinensis (Lour.) Moore ssp. laurina (Retz.) Nooteboom (Symplocaceae), Meenumutty, Feb. 20, 1983, V.B. Hosagoudar, HCIO 40564; MH 75875; Idukki, Aug. 20, 1983, V.B. Hosagoudar MH 75876; Calvary Mount, Oct. 5, 1983, V.B. Hosagoudar MH 72162.

78. **Meliola tamarindi** H. Sydow & P. Sydow, Ann. Mycol. 10: 79, 1912.

On leaves of Tamarindus indica L. (Caesalpiniaceae), Tanikandam, Dec. 16, 1982, V.B. Hosagoudar, HCIO 40565; MH 75785.

Sydow & Sydow (1912) described this species from the Philippines. Later, Hansford & Deighton (1948) reexamined the material. The present collection matches it well.

79. **Meliola tecleae** Hansf. var. **toddaliae-asiaticae** Hansf., Proc. Linn. Soc. London 153:11, 1941.

On leaves of Toddalia asiatica (L.) Lam. (Rutaceae), Idukki, Dec. 12, 1982, V.B. Hosagoudar, HCIO 40567; MH 75714; Feb. 19, 1983, V.B. Hosagoudar, 75852; Dec. 21, 1983, V.B. Hosagoudar, MH 78923.

80. **Meliola themedae** Stev. & Rold. ex Hansf. var. **indica** Hosagoudar, var. nov. Fig. 34.

Differt a M. themedae Stev. & Rold. ex Hansf. var. themedae hyphopodiis capitatis magnioribus et setis myceliorum longioribus, simplicibus, acutis et obtusis.

Colonies amphigenous, subdense, velvety, up to 2 mm in diameter, confluent. Hyphae straight to tortuous, straight hyphae run along the veins and tortuous hyphae across the straight hyphae, branching mostly opposite at acute to wide angles, closely reticulate and form almost solid mycelial mat. Capitate hyphopodia alternate, spreading, antrorse to reflexed, straight to curved, 20-30 µm long; stalk cells cylindrical to cuneate, 8-14 µm long; head cells ovate, angular, entire to imperfectly and irregularly sublobate, 10-16 x 10-14 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 14-20 x 6-10 µm. Mycelial setae scattered to grouped around perithecia, straight, simple, acute to obtuse at the tip, up to 558 µm long. Perithecia scattered, verrucose, up to 130 µm; spores obovoidal, 4-septate, constricted, 40-48 x 14-18 µm.

Holotype: On leaves of Themeda cymbaria Hack. (Gramineae), Calvary Mount, Jan. 8, 1982, V.B. Hosagoudar, HCIO 40568; MH 72611, Isotype. Paratypes: Meenumutty, Dec. 12, 1982, V.B. Hosagoudar, MH 75708; Dec. 21, 1983, V.B. Hosagoudar, MH 78958.

Stevens and Roldan (1935) described Meliola themedae on Themeda gigantea (Cav.) Hack. from the Philippines. The new variety differs from the var. themedae in having larger capitate hyphopodia, and longer, simple, acute to obtuse mycelial setae.

81. **Meliola tylophorae** Hosagoudar, sp. nov. Fig. 35.

Plagulae amphigenae, plerumque hypophyllae, densae, velutinae, ad 5 mm diam., confluentes. Hyphae rectae vel leniter undulatae, oppositae acuteque vel laxe ramosae, densae vel laxe reticulatae, cellulis 12-30 x 6-8 µm. Hyphopodia capitata alternata vel ad 60% opposita, antrorsa, patentia, recta vel curvula, 16-20 µm longa; cellula basali cylindracea vel cuneata, 4-8 µm longa; cellula apicali ovata, globosa, integra, 10-14 x 8-10 µm. Hyphopodia mucronata et capitata commixta, opposita vel alternata, ampullacea, 12-24 x 6-10 µm. Setae myceliales dispersae vel etiam juxta perithecia aggregatae, simplices, acutae vel obtusae, ad 468 µm. Perithecia plerumque aggregata, verrucosa, ad 252 µm; sporae obovoidae, 4-septatae, constrictae, 34-42 x 14-18 µm.

Colonies amphigenous, mostly hypophyllous, dense, velvety, up to 5 mm in diameter, confluent. Hyphae straight to slightly undulating, branching opposite at acute to wide angles, loosely to closely reticulate, cells 12-30 x 6-8 µm. Capitate hyphopodia alternate and about 60% opposite, antrorse, spreading, straight to curved, 16-20 µm long; stalk cells cylindrical to cuneate, 4-8 µm long; head cells ovate, globose, entire, 10-14 x 8-10 µm. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 12-24 x 6-10 µm. Mycelial setae scattered to grouped around perithecia, simple, acute to obtuse at the tip, up to 468 µm long. Perithecia mostly grouped, verrucose, up to 252 µm; spores obovoidal, 4-septate, constricted, 34-42 x 14-18 µm.

Holotype: On the leaves of Tylophora caparidifolia Wight & Arn. (Asclepiadaceae), Calvary Mount, Feb. 21, 1983, V.B. Hosagoudar, HCIO 40569; MH 75885, Istopyte.

The new species is very close to M. hoyae Sacc. but differs from it in larger perithecia, smaller ascospores and longer mycelial setae. Thite & Patil (1982) recorded M. telosmae Rehm var. tylophorae Hansf. on Tylophora sp. from Maharashtra. The present species differs from it in having larger, opposite and alternate capitate hyphopodia, larger setae, larger perithecia and ascospores.

82. **Meliola weberae** Kapoor, Indian Phytopath. 20: 159, 1967.

On leaves of *Tarenna asiatica* (L.) Sant. Merch. (*Chomelia asiatica* O. Kze, *Webera corymbosa* Wild.) (Rubiaceae), Pamba, Oct. 10, 1983, V.B. Hosagoudar, HCIO 40570; MH 78921.

83. ***Meliola wendlandiae*** Hosagoudar, sp. nov. Fig. 36.

Plagulae amphigenae, plerumque hypophyllae, subdensae, subvelutinae, ad 4 mm diam., confluentes. Hyphae sinuosae vel anfractae, oppositae vel irregulariter acuteque ramosae, densae vel laxe reticulatae, cellulis 18-32 x 6-10 µm. Hyphopodia capitata alternata, antrorsa, patentia, 20-30 µm longa; cellula basali cuneata vel cylindracea, 6-12 µm longa; cellula apicali ovata, ad apices subrotunda, leniter angulosa, integra, 15-18 x 12-14 µm. Hyphopodia mucronata plerumque in hyphis distinctis evoluta, alternata vel opposita, ampullacea, 14-20 x 8-10 µm. Setae myceliales paucae, etiam juxta perithecia aggregatae, simplices, rectae, subacutae vel acutae ad apices, ad 344 µm longae. Perithecia, dispersa, verrucosa, ad 168 µm; sporae obovoidae, 4-septatae, constrictae, 36-46 x 12-18 µm.

Colonies amphigenous, mostly hypophyllous, subdense, subvelvety, up to 4 mm in diameter, confluent. Hyphae sinuous to crooked, branching opposite to irregular at acute angles, loosely to closely reticulate, cells 18-32 x 6-10 µm; stalk cells cuneate to cylindrical, 6-12 µm long; head cells ovate, narrow towards apex, slightly angular, entire, 15-18 x 12-14 µm. Mucronate hyphopodia borne on a separate mycelial branch, alternate to opposite, ampulliform, 14-20 x 8-10 µm. Mycelial setae few, grouped around perithecia, simple, straight, acute to subacute at apex, up to 344 µm long. Perithecia scattered, verrucose, up to 168 µm; spores obovoidal, 4-septate, constricted, 36-46 x 12-18 µm.

Holotype: On leaves of *Wendlandia notoniana* Wall. (Rubiaceae), near Painavu, April 18, 1982, V.B. Hosagoudar, HCIO 40571; MH 72692, Isotype. *Paratype*: Oct. 3, 1983, V.B. Hosagoudar MH 78131.

Thite & Kulkarni (1973) recorded *M. canthi* Hansf. on *W. notoniana* Wall. from Maharashtra. The new species differs in having hypophyllous colonies, crooked mycelia, entire, straight head cells of the capitate hyphopodia, mucronata hyphopodia borne on separate mycelial branches, and in having smaller ascospores.

84. ***Meliola zizyphi*** Hansf. & Thirum., Farlowia 3: 299, 1948.

On leaves of *Zizyphus xylopyrus* Willd. (Rhamnaceae), Idukki, Dec. 28, 1983, V.B. Hosagoudar, HCIO 40572; MH 80328. On leaves of *Z. trinervia* Roxb., Idukki, Oct. 22, 1984, A. Diraviadoss; MH 82602.

The collections cited differ slightly from the description in having smaller, dentate mycelial setae and smaller ascospores.

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We are grateful to the following Scientists of Botanical Survey of India, Southern Circle, Coimbatore for their help in various ways: Drs. N.C. Nair, N.P. Balakrishnan, V.J. Nair and Messrs. B.V. Shetty, K. Vivekanathan and K. Sivanandan. We extend our sincere thanks to Drs. U. Braun (Germany), K. Katumoto (Japan) and W.A. Cavalcanti (Brazil) for their valuable suggestions and also for providing the literature on the topic. We are especially grateful to Dr. F. A. Uecker, Dr. K. Pirozynski and Dr. S.J. Hughes for reviewing the manuscript and for many helful suggestions, and to Dr. R.P. Korf for editorial assistance.

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Figs. 1-36. New taxa of meliolaceous fungi. Key to abbreviations: Ch = capitate hyphopodia. Mh = mucronate hyphopodia. Sp = spore. Pc = perithecial cell. Ps = perithecial setae. Ms = mycelia setae. All Figs. drawn to scale indicated.

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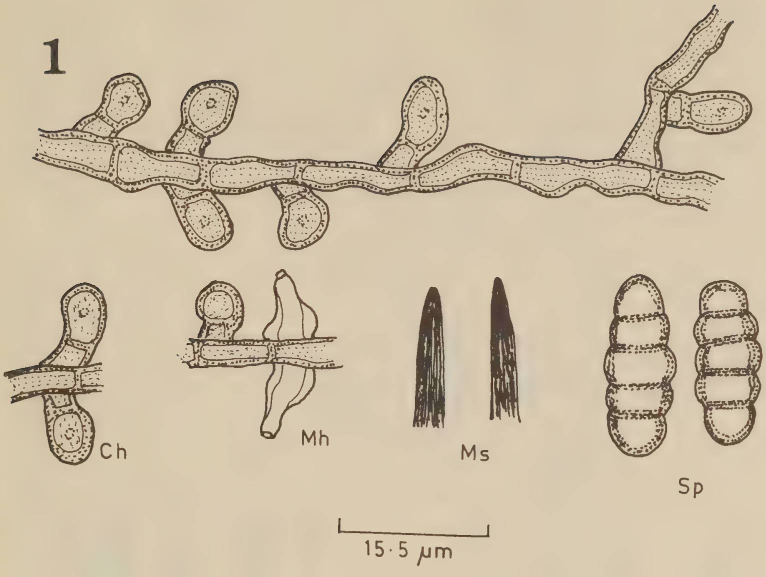
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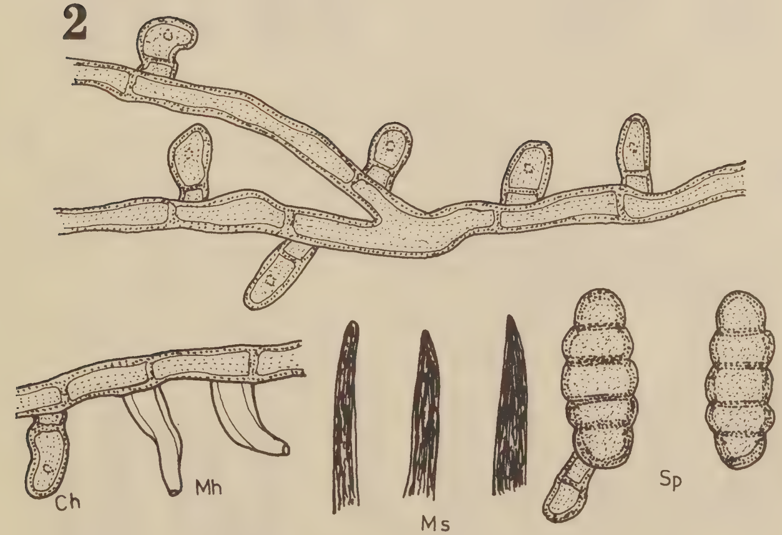

Fig. 1. Meliola ancistrocladii Hosagoudar. Fig. 2 Meliola angiopteridis Hansf. var. indica Hosagoudar.

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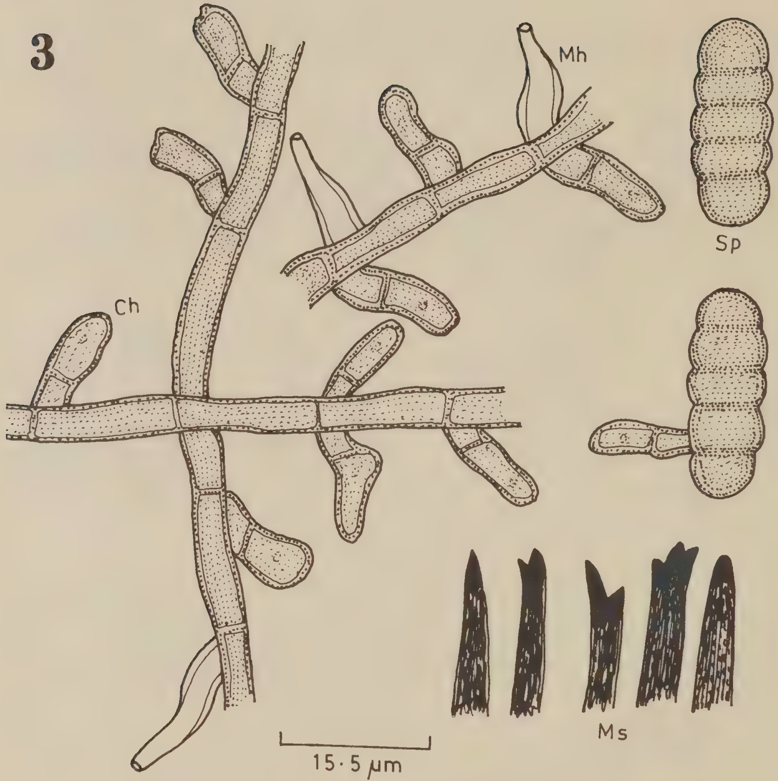
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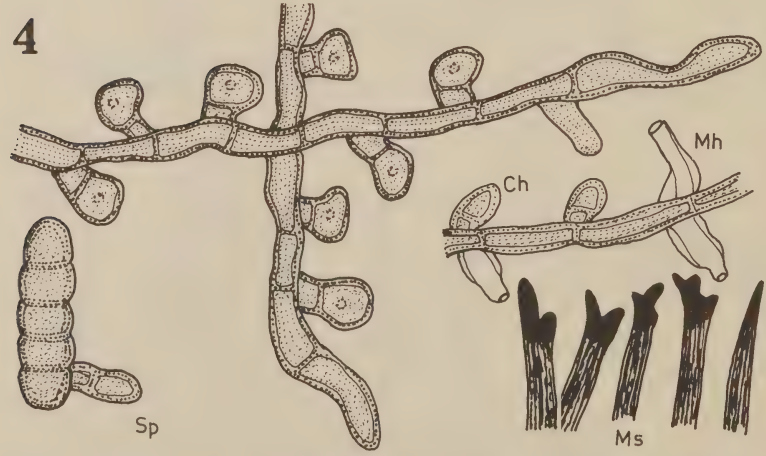

Fig. 3. Meliola atalantiae Hosagoudar. Fig. 4. Meliola atylosiae Hosagoudar.

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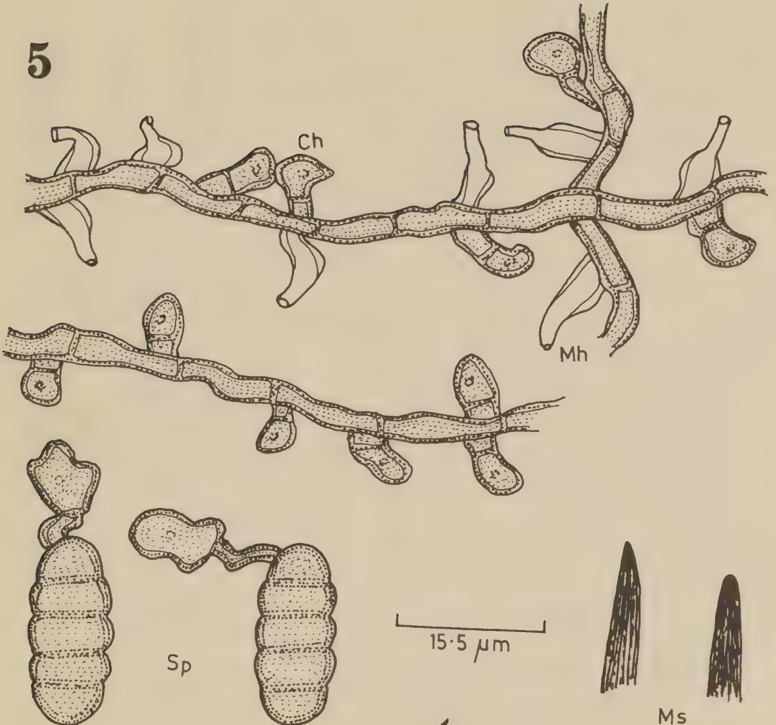
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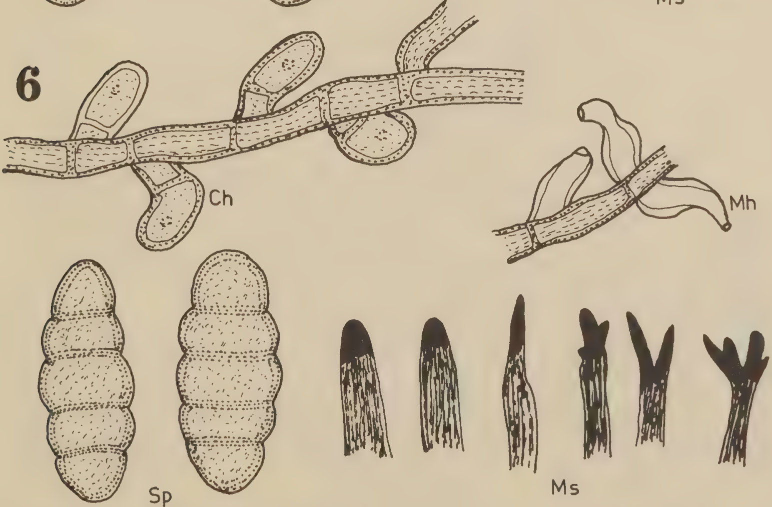

Fig. 5. Meliola bantamensis Hansf. var. keralensis Hosagoudar. Fig. 6. Meliola beilschmiediae Yamam. var. cinnamomicola Hosagoudar.

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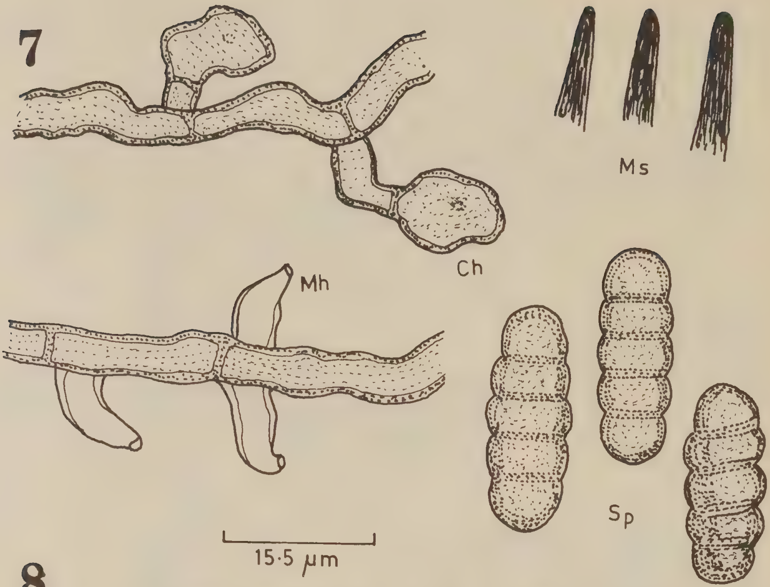
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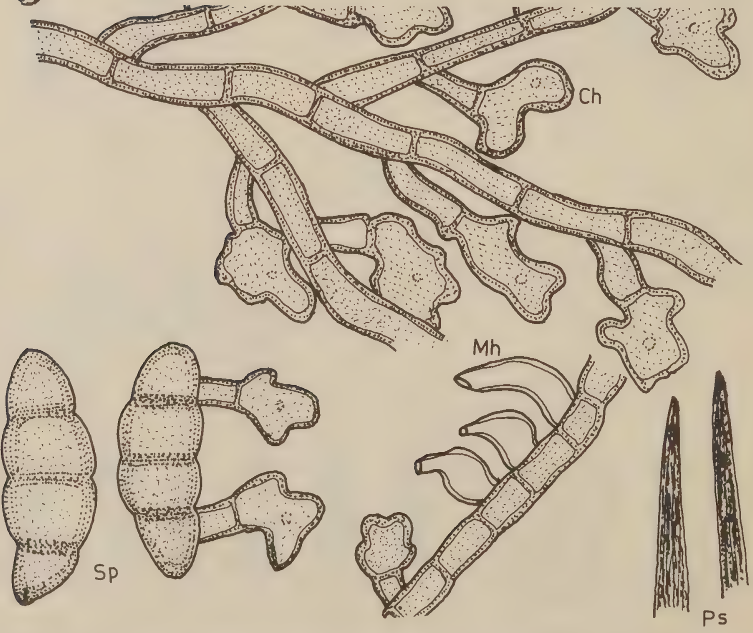

Fig. 7. *Meliola buchananiicola* Hosagoudar. Fig. 8. *Meliola cansjericola* Hosagoudar.

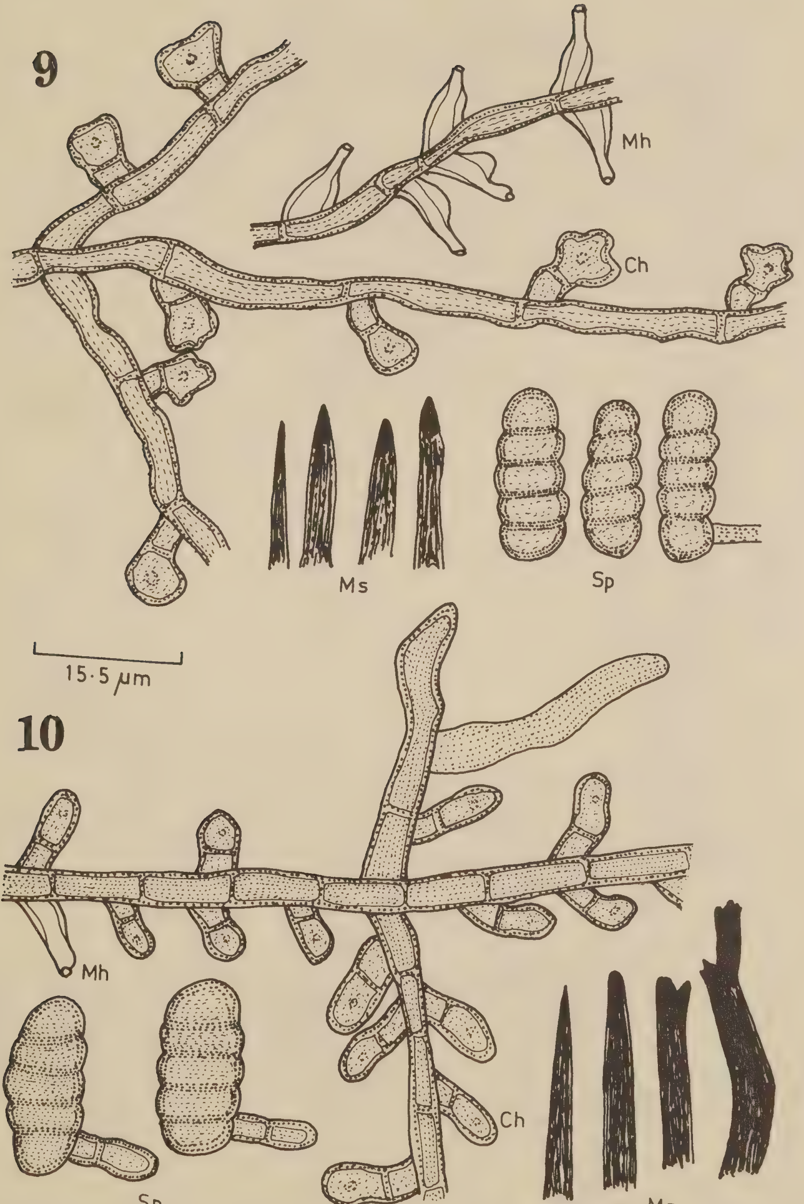
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Fig. 9. Meliola chandrasekharanii Hosagoudar. Fig. 10. Meliola clausenae Hosagoudar.

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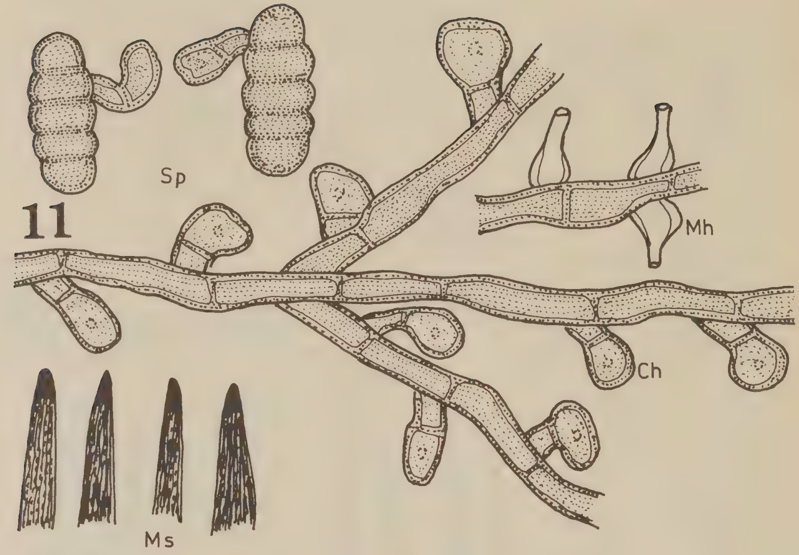

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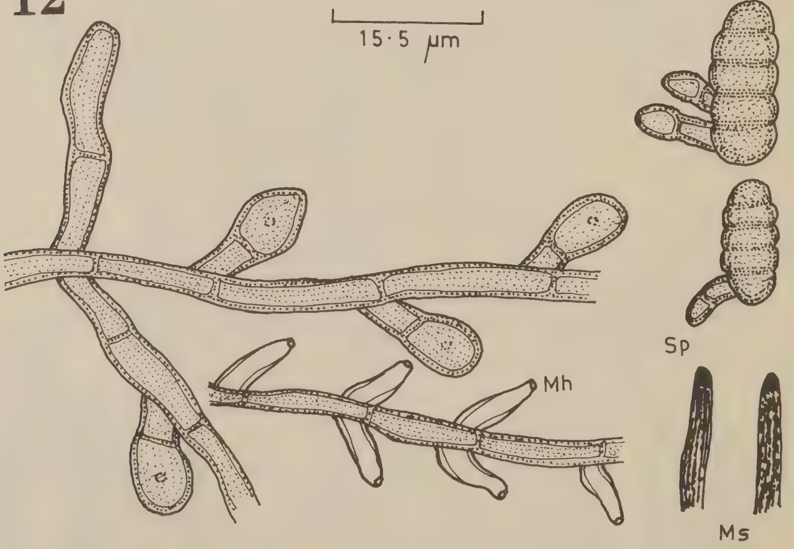
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Fig. 11. Meliola clitoriae Hosagoudar. Fig. 12. Meliola cycleae Hosagoudar.

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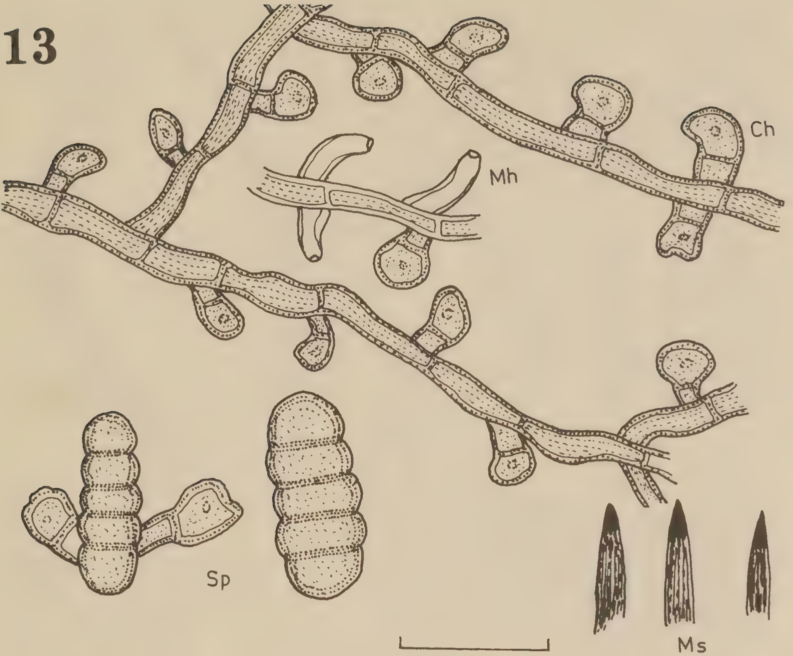

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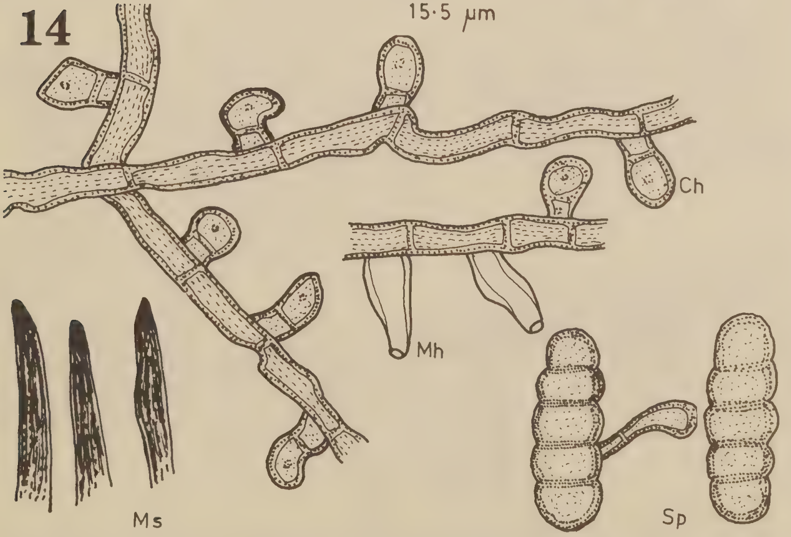
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Fig. 13. *Meliola dimidiatae* Hosagoudar. Fig. 14. *Meliola drypeticola* Hosagoudar.

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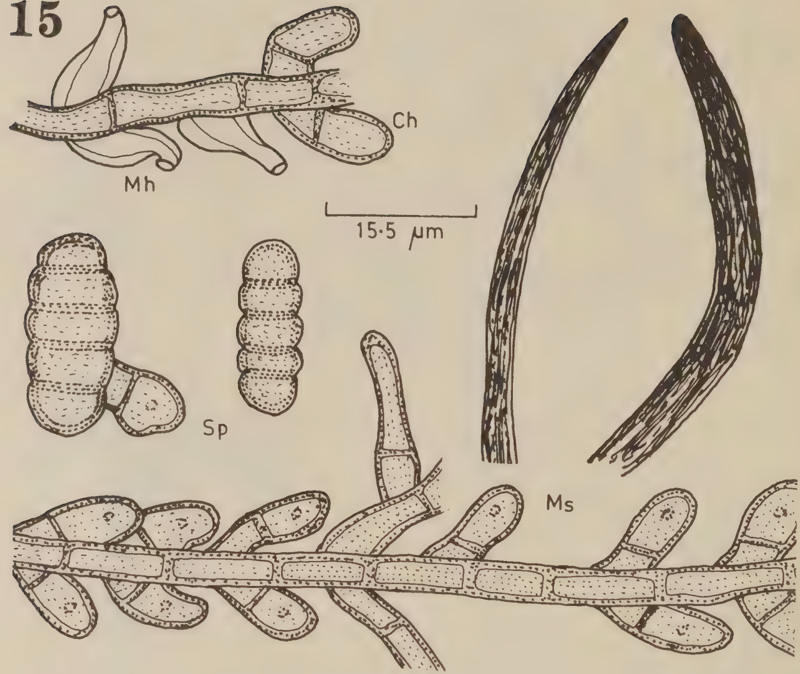
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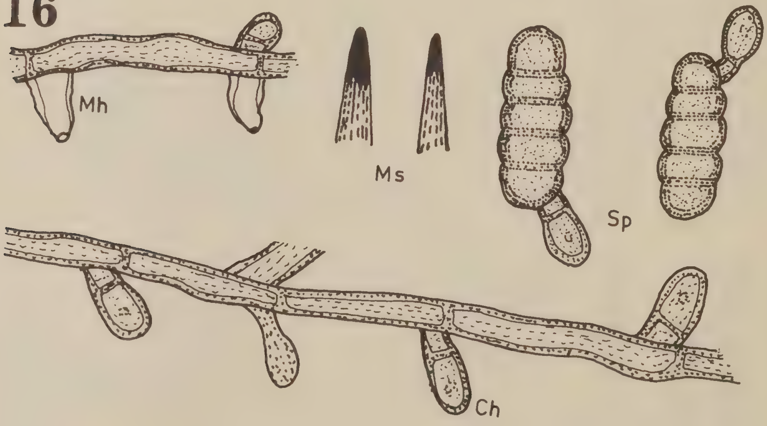

Fig. 15. *Meliola erycibis-paniculatae* Hosagoudar. Fig. 16. *Meliola erythropalii* Hosagoudar.

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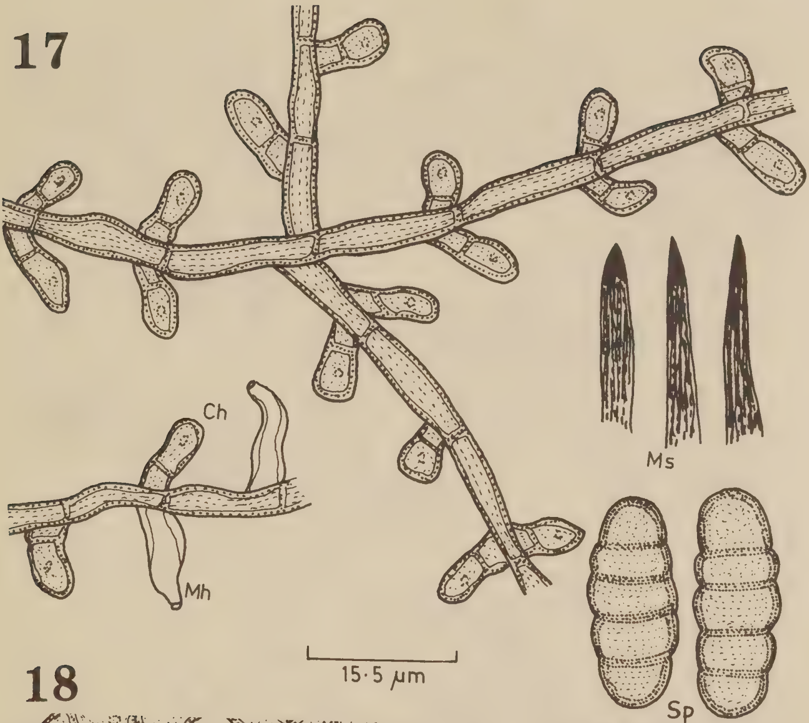
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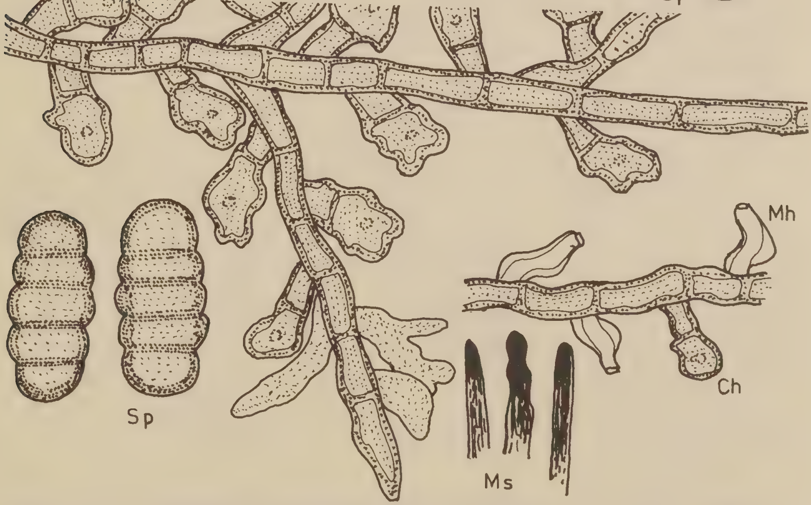

Fig. 17. Meliola glochidii Stev. & Rold. ex Hansf. var. velutini Hosagoudar. Fig. 18. Meliola hunteriae Hosagoudar.

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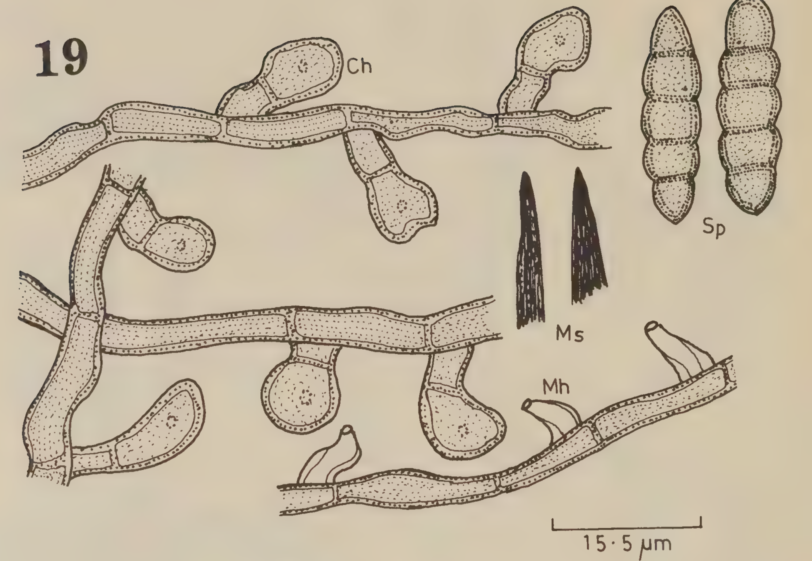
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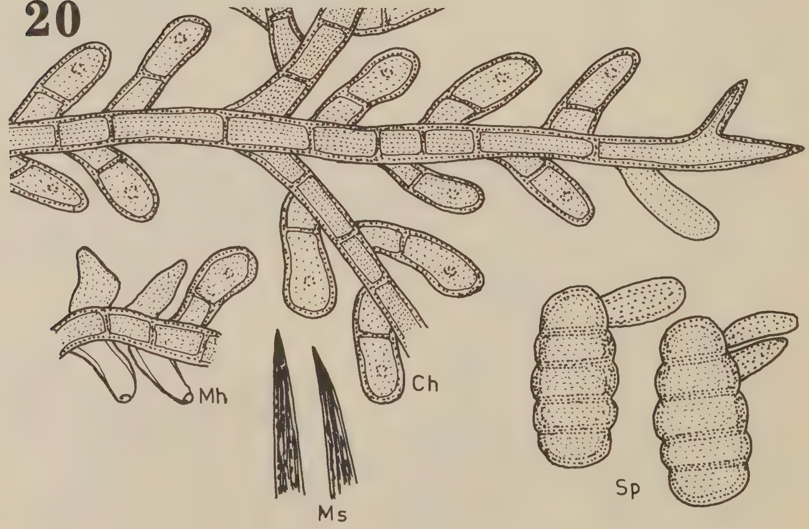

Fig. 19. *Meliola ixorae* Yates var. *macrospora* Hosagoudar.
Fig. 20. *Meliola ligustri* Hosagoudar.

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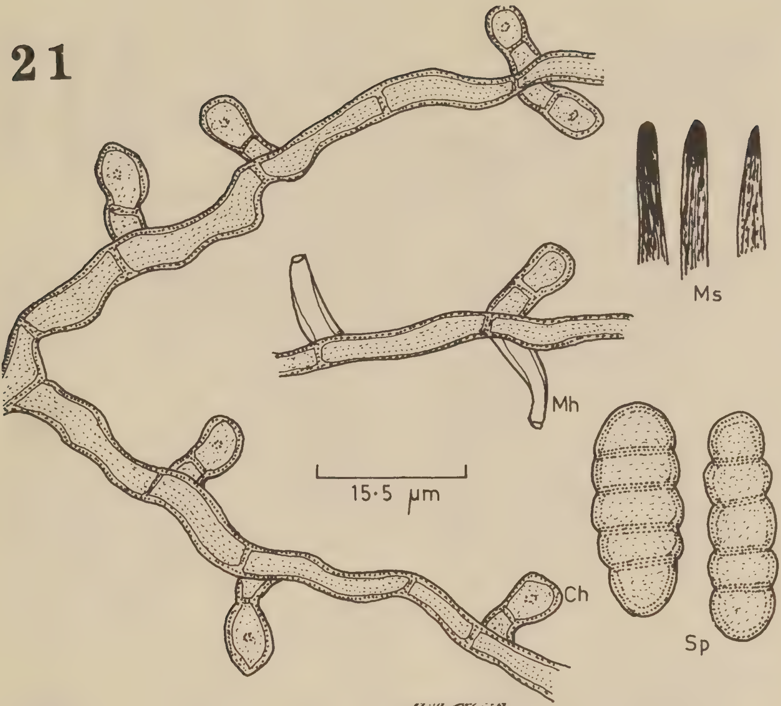
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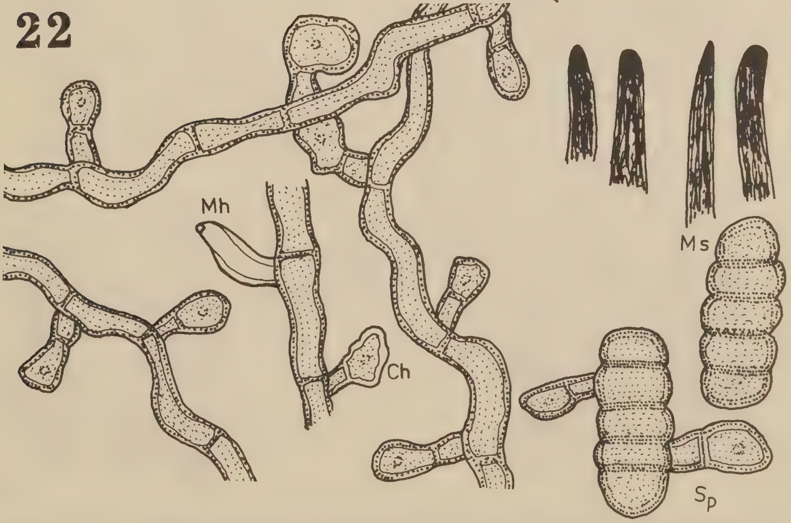
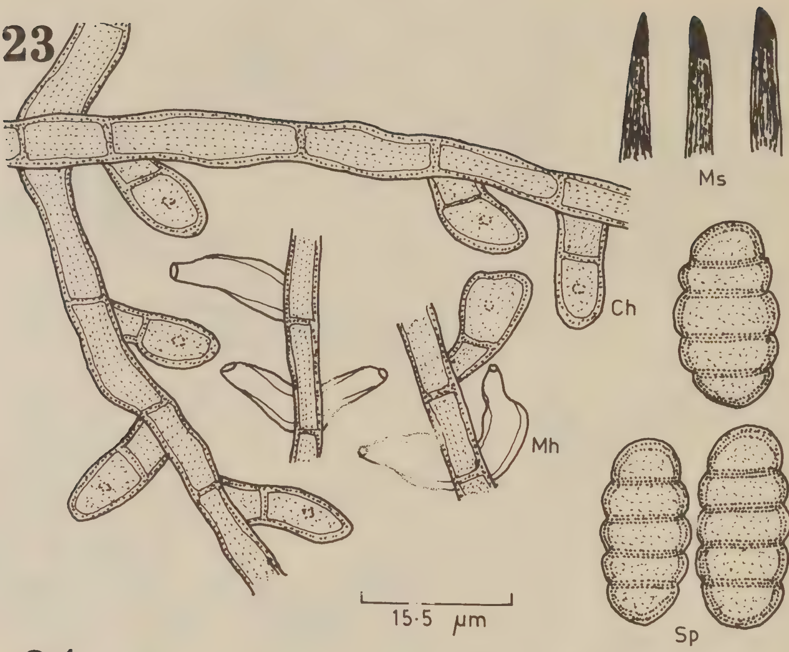


Fig. 21. *Meliola litseae* Sydow & Sydow var. *floribundae* Hosagoudar. Fig. 21. *Meliola litseae* Sydow Sydow var. *insignis* Hosagoudar.

23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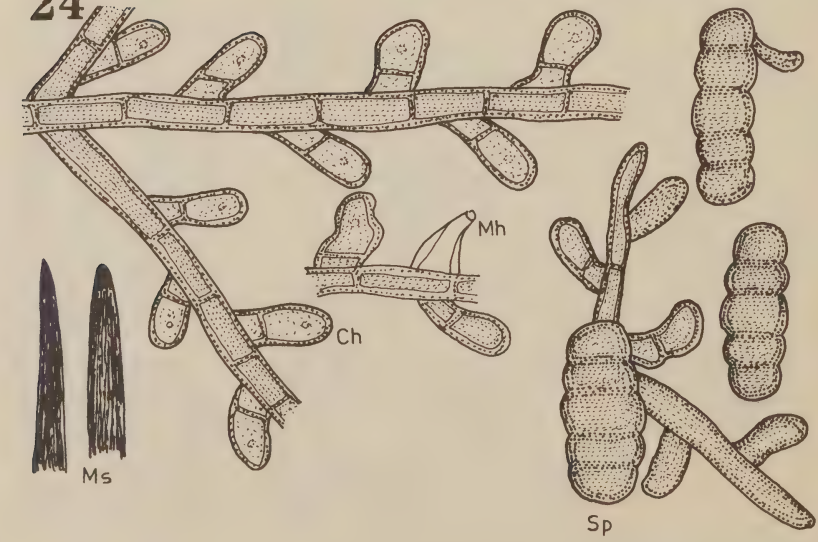
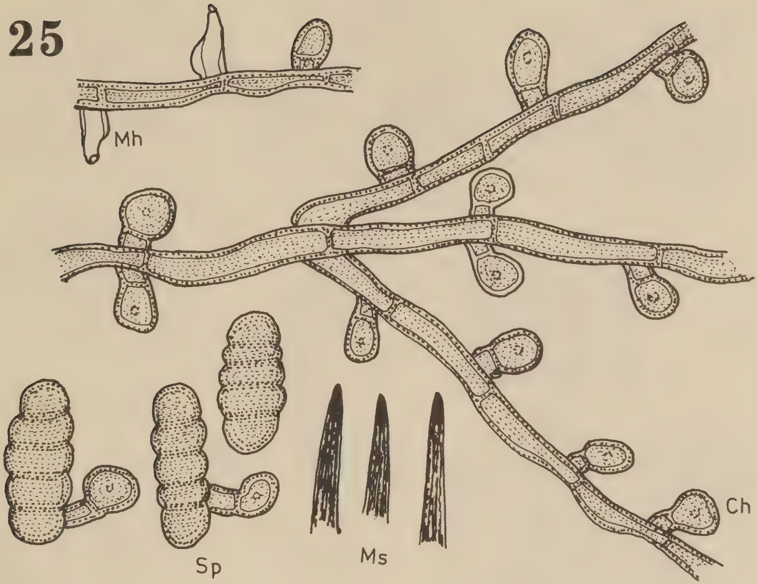


Fig. 23. Meliola litseae Sydow & Sydow var. keralense.
Fig. 24. Meliola luvungae Hosagoudar.

25



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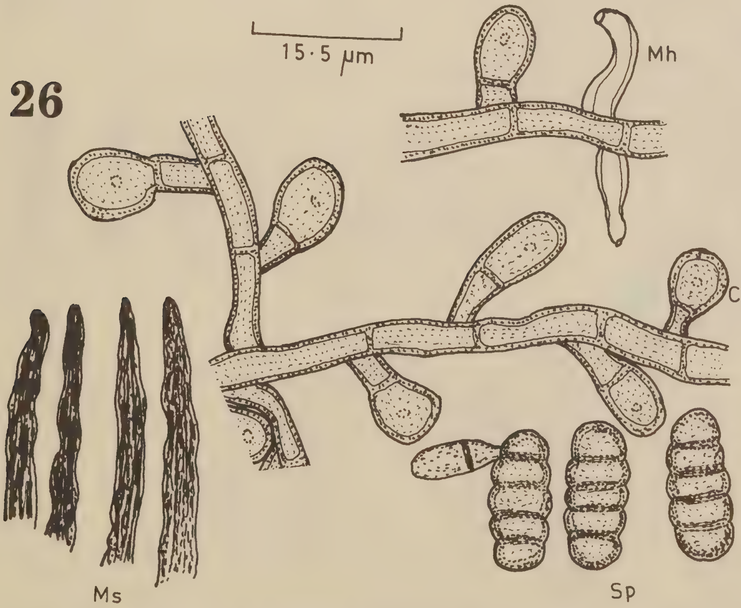
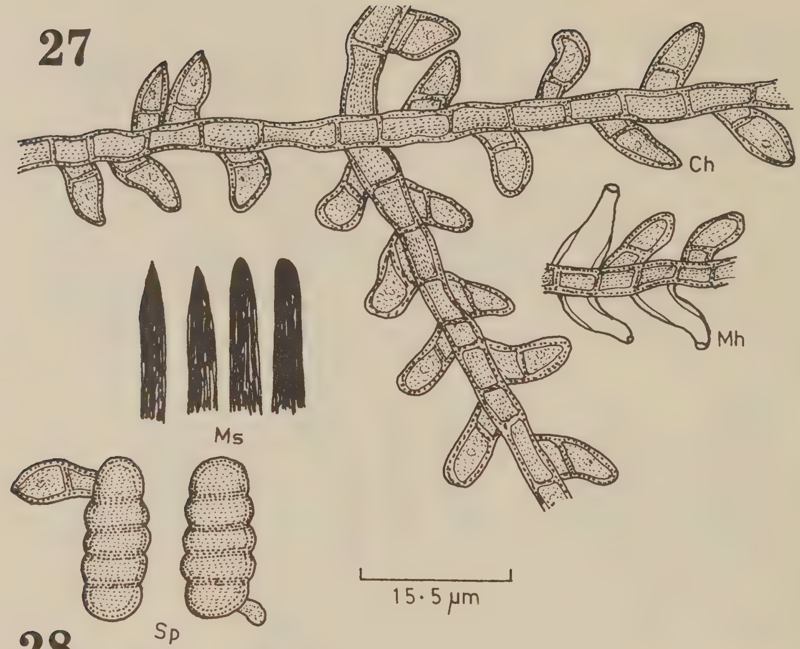

15·5 µm
Mh
Ch
Ms
Sp

Fig. 25. *Meliola mucunae* Hansf. var *hirsutae* Hosagoudar.
Fig. 26. *Meliola nilgirianthii* Hosagoudar.

27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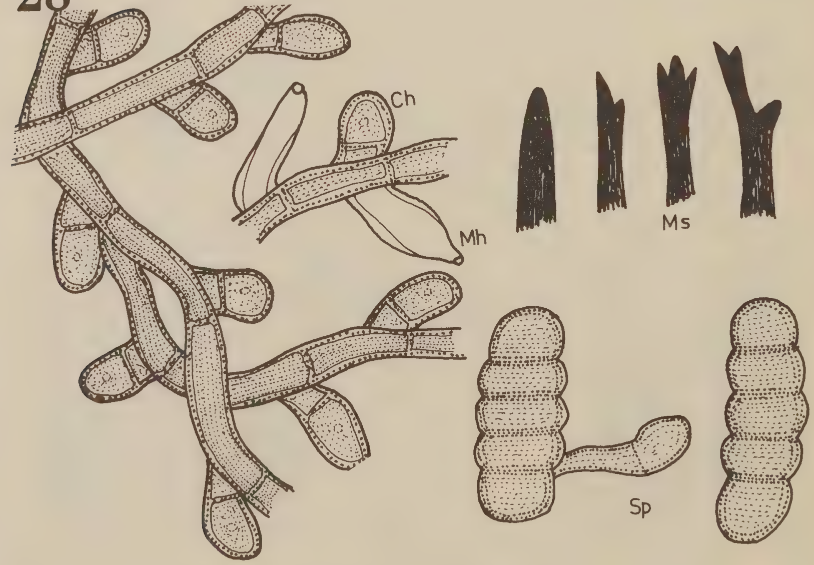
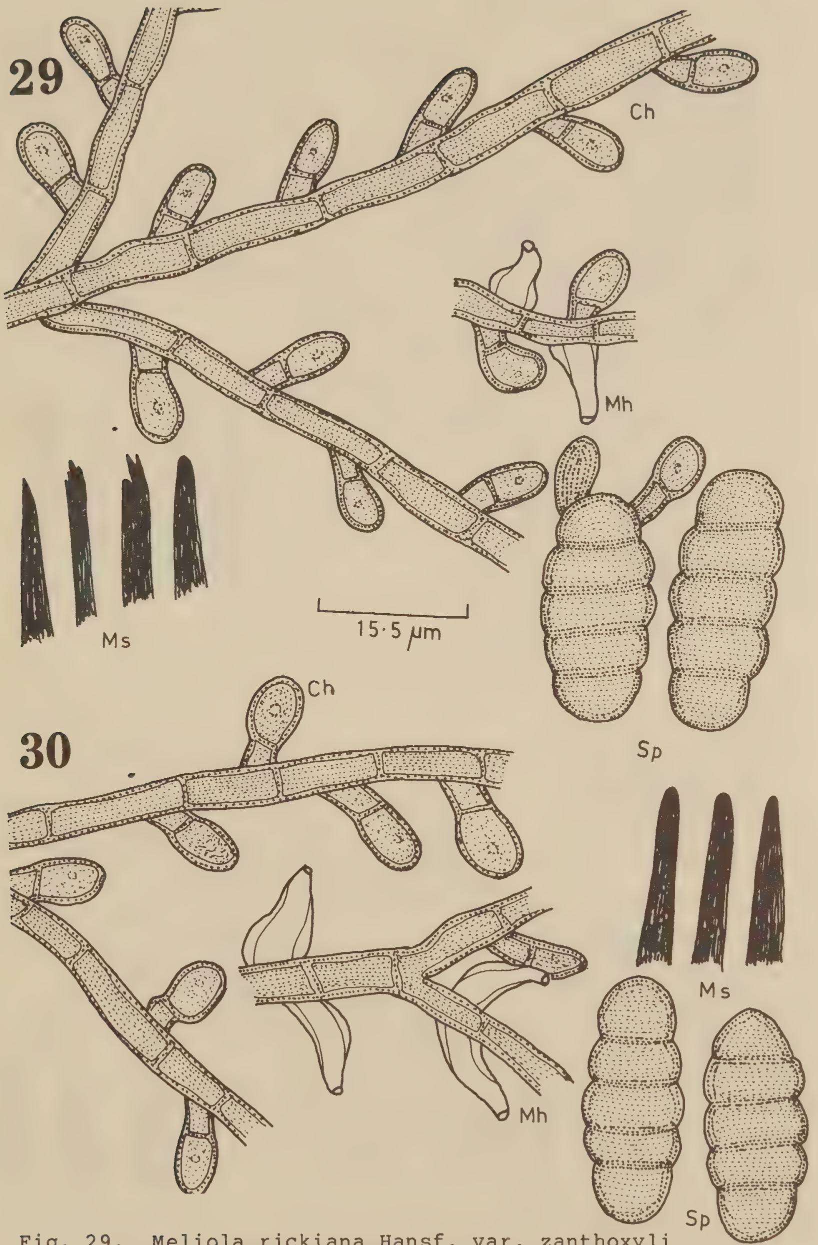


Fig. 27. *Meliola otonephelii* Hosagoudar. Fig. 28. *Meliola premnicola* Housagoudar.


29
Ch
Mh
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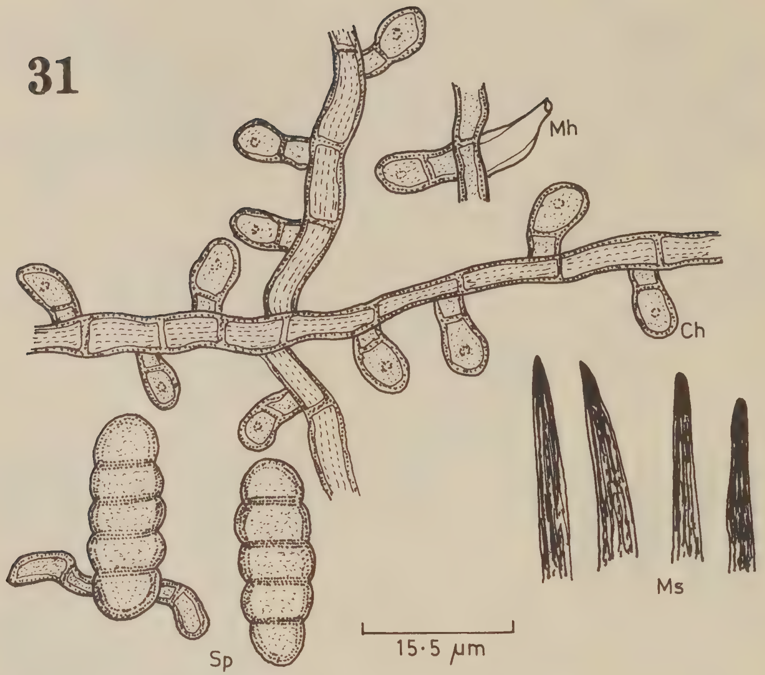
Sp
30
Ch
Mh
Ms
Sp

Fig. 29. Meliola rickiana Hansf. var. zanthoxyli Hosagoudar. Fig. 30. Meliola salleana Hansf. var. smilacis Hosagoudar.

31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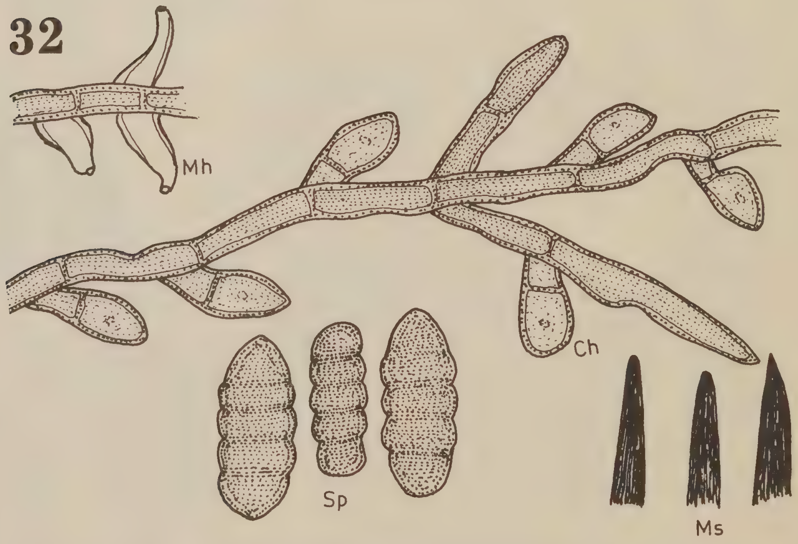
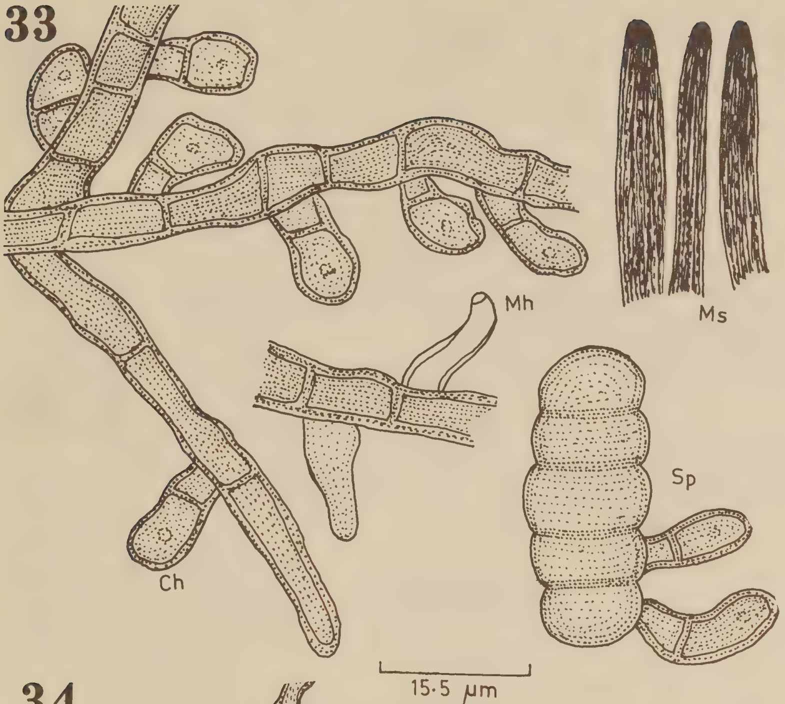


Fig. 31. Meliola sarcostigmae Hosagoudar. Fig. 32. Meliola scleropyri Hosagoudar.

33


Mh
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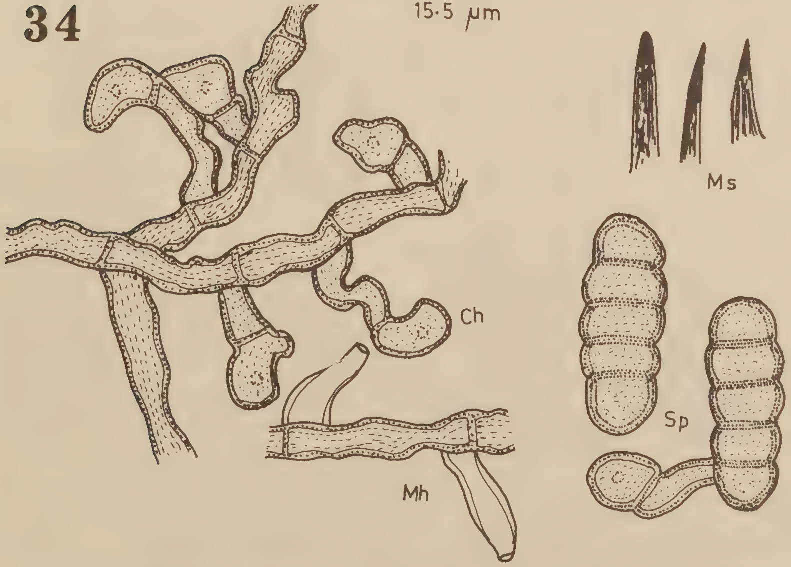
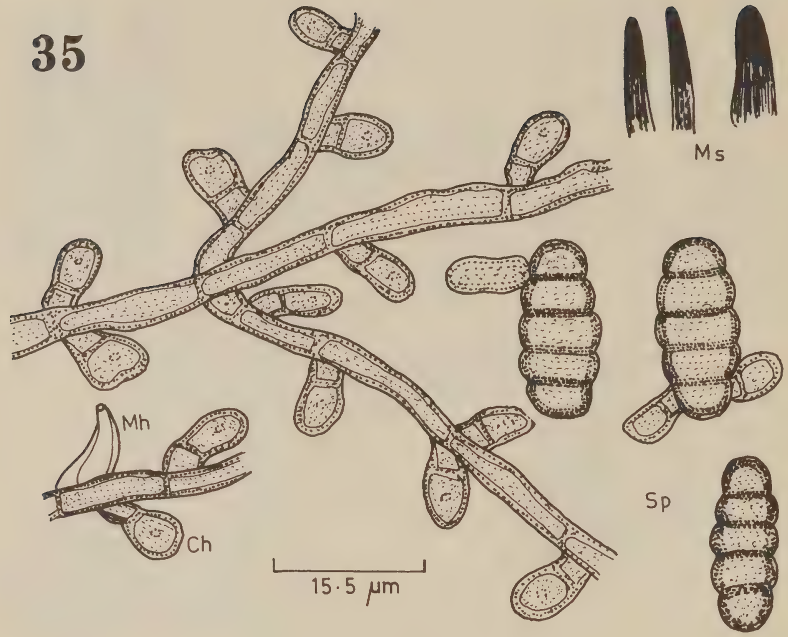


Fig. 33. *Meliola stemonuri* Hosagoudar. Fig. 34. *Meliola themedae* Stev. & Rold var. *indica* Hosagoudar.

35


Ms
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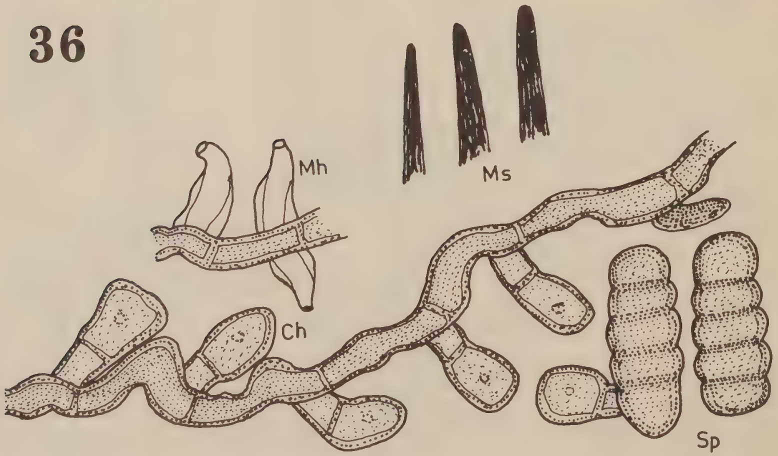

Fig. 35. Meliola tylophorae Hosagoudar. Fig. 36. Meliola wendlandiae Hosagoudar.

MYCOTAXON

Vol. XXXVII, p. 273 April-June 1990

A NEW PYRENOMYCETE RECORD FOR THE NEW WORLD

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Sarawakus lycogaloides (Berk. & Br.) Lloyd has been found on the bole of a recently downed sweet gum tree (*Liquidambar styraciflua* L.), in Florida, USA. The known western distribution of *S. lycogaloides* is further expanded by two collections from French Guiana (Samuels, 1987).

Rifai (1969) reported the distribution of this fungus to be Ceylon (Sri Lanka), Borneo, and Java. Pohlad and Reynolds (1974) found a similar Indonesia/Florida, USA, distribution for the Pyrenomycete *Treubiomyces pulcherrimus* von Höhnel.

Western collection sites:

- Alachua, Co., Florida, USA. San Felasco Hammock forest research area. T9S, R18E, SEC12, SE quadrant. 13 Jan. 1987. DLN 205, deposited NY.
- French Guiana. Saül. 3-16 Feb. 1986. Samuels 3739, deposited NY.
- French Guiana. Paul Isnard area, Mts. Lucifer and Decou Decou. 7-17 March 1986. Samuels 4102, deposited NY.

A description and illustrations of *S. lycogaloides* are provided by Rifai (1969).

Acknowledgements:
Special thanks go to Dr. Gary Samuels for his assistance. I thank Drs. Gary Samuels and Amy Rossman for their review of this note. The National Science Foundation supports the Pyrenomycete research of Drs. C.T. Rogerson and Gary Samuels (NSF BSR 8500236).

Literature Cited:

Pohlad, B.R., & D.R. Reynolds. 1974. *Treubiomyces* rediscovered. Mycologia 66(3):521-524.

Rifai, M.A. 1969. *Sarawakus* Lloyd, a genus of the Pyrenomycete family Hypocreaceae. Reinwardtia 7(5):561-578.

Samuels, G. 1987. Personal communication.

MYCOTAXON

Vol. XXXVII, pp. 275-290 April-June 1990

MORPHOLOGY AND ONTOGENY OF CONIDIA IN *WILSONOMYCES CARPOPHILUS, GEN. NOV.* AND *COMB. NOV.*, CAUSAL PATHOGEN OF SHOT HOLE DISEASE OF *PRUNUS* SPECIES

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SUMMARY

The new genus *Wilsonomyces* is described and the new combination *W. carpophilus* is proposed based on colony characteristics, morphology of conidia, and conidial ontogeny. Cultures, living plant material, and herbarium specimens were examined using bright-field, phase contrast, scanning, and transmission electron microscopy. Cultures observed were grown on various media at 5, 8, 15, 22, 27, 30, and 34 C. Diseased leaves from almond plants inoculated with *W. carpophilus* and incubated in growth chambers at 8, 15, and 22 C were also examined. Conidial development, in cultures and in plant tissue, occurred holoblastically on a sympodially developing conidiogenous cell (sympodulophore). Two septa delineated the conidium from the conidiogenous cell, and separation occurred by rhexolysis. Morphological studies of herbarium samples of *Stigmina platani*, *S. platani-racemosae* (type specimen), *S. pulviniformis*, and *S. compacta* indicated that conidia of these fungi were densely verrucose and formed holoblastically by percurrent development of conidiogenous cells (annellides). These conidiophores commonly had several annellations from previously formed conidia.

In 1843, J. H. Léveillé described *Helminthosporium carpophilum*. Others subsequently described the organism resulting in numerous synonyms including *Macrosporium rhabdiferum* Berk., *Sporidesmium amygdalearum* Pass., and *Coryneum beyerinckii* Oud. In 1901, Aderhold made the combination *Clasterosporium carpophilum* (Lév.) Aderh. Many researchers in North America, however, continued to use *C. beyerinckii*, following the publication on peach blight in California by Smith *et al.* (1907). Researchers in Europe and Australia, however, used Aderhold's combination. This difference in nomenclature, as reviewed by Samuel (1927), was largely based on disease development on different host tissues. On stem tissue, the fungus produced a well developed stroma interpreted as an acervulus, justifying its taxonomic placement in the genus *Coryneum* Nees: Fr. of the Melanconiales. On leaf tissue, however, the stroma was not well developed and the fungus was considered similar to other hyphomycetous fungi. For this reason, the fungus was placed in the genus *Clasterosporium* Schw. Jauch (1940) maintained the fungus in the genus *Coryneum* as *C. carpophilum* (Lév.) Jauch.

Ellis (1959), after studying fungi in *Clasterosporium* and other allied genera with phaeophragmospores, transferred the shot hole fungus to the genus *Stigmina*. This new combination was based primarily on conidial ontogeny and disease development. Ellis considered the conidiophore to be an annellide and the fungus to produce conidia and sporodochia similar to those of other species in the genus *Stigmina*. Ellis also noted that conidiophores developed laterally beneath conidial scars when the fungus was grown in culture or under conditions of high humidity.

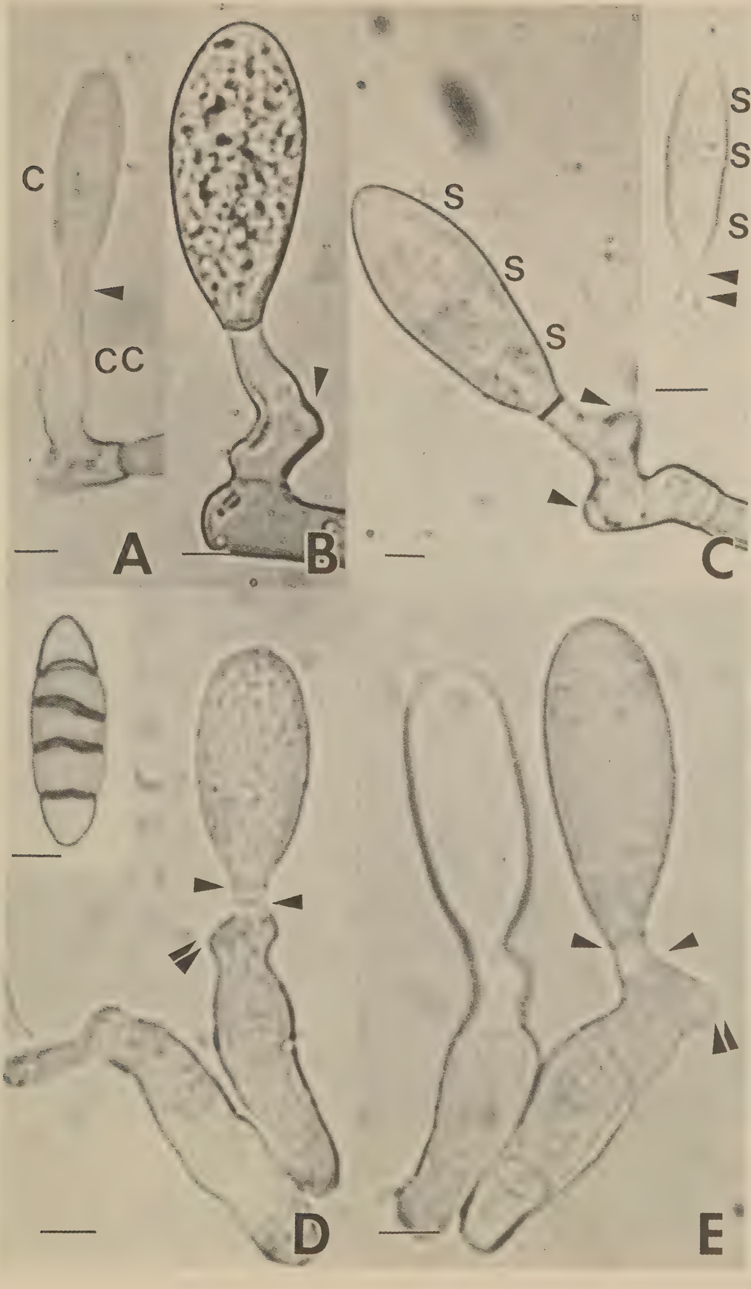
Changes in nomenclature for this fungus reflect changes in criteria used in classification of Deuteromycotina. The original classification system for hyphomycetes was developed by Saccardo (1886) and was based primarily on characteristics of conidia including shape, color, and septation. This system, however, did not reflect natural relationships between taxa and led to inconsistencies in classification (Cole, 1986). Studies of conidial ontogeny in the Deuteromycotina were used to develop a new classification system (Hughes 1953). Such a system would group related organisms based on conidial development and reproductive cell structure. A complication, however, is that some fungi exhibit more than one method of conidial development (Wingfield, 1985; Glawe and Rogers, 1984). Further, conidial development may be influenced by environmental conditions (Pollack and Matthews, 1976), or mutations (Clutterbuck, 1969). This variability makes the classification of some fungi difficult and necessitates taxonomic studies that carefully examine critical morphological characteristics, such as spore ontogeny, under various environmental conditions.

The purpose of this paper was to determine the method of conidial ontogeny, the influence of temperature and media on conidial development, to evaluate cultural and colony (*in situ*) characteristics of the fungus, and to reassess its generic placement.

MATERIALS AND METHODS

Specimens and Cultures. Collections and cultures made by the

Figure 1. **A-E.** Developing conidia and conidiophores of *W. carpophilus* from culture and from field collected almond leaf tissue (*Prunus dulcis* var. Price). Bars = 5 µm. **A-C.** Conidia and conidiophores from culture (JEA 637). **A.** Early stage of conidial development (C) from newly formed conidiogenous cell (CC). Basal septum of conidium barely visible (arrow). **B.** Developing conidium with some lateral enlargement but no intercalary septa visible. Basal septum separates conidium from first sympodial branch of conidiogenous cell (arrow indicates where a conidium was previously attached). **C.** Later stage of a developing conidium with the basal septum well developed and with 3 intercalary septa (s) forming. Conidium on second sympodial branch of conidiophore (arrows indicate where 2 conidia were previously attached). **Inset.** A late stage of a developing conidium with 3 well developed intercalary septa (s). Arrows indicate a zone without cytoplasm between the basal septum and a septum in the conidiogenous cell. **D-E.** Conidia and conidiophores from field material (JEA 1190). **D.** Later stage of a developing conidium with some lateral enlargement. Single arrows indicate 2 septa delineating the conidiogenous cell from the conidium as in the inset of Fig. C. Double arrow indicates a scar where a conidium was previously attached. **Inset.** Mature conidium. **E.** Late stage in a developing conidium with intercalary septa and double septa (single arrows) delineating conidium from sympodial branch. Double arrow indicates where a conidium was previously attached.


C
CC
A
B
S
S
S
S
S
S
C
D
E

authors were: JEA637, on leaves of *Prunus dulcis* (almond), Delhi, Merced County, CA,; JEA770 and JEA1350, on twigs of *P. persica* (L.) Batsch (peach), Davis, Yolo County, CA; JEA797, on fruit of *P. armeniaca* L. (apricot), Davis, Yolo County, CA; and JEA798 and JEA1351 on leaves of *P. dulcis*, Davis, Yolo County, CA.

Specimens examined from the Farlow Herbarium were: *Sporidesmium amygdalearum* Pass. f. *armeniacae*, on *Prunus armeniaca*, Parma, G. Passerini, 1876, Thümen's Mycotheca Univ. No. 474, type; *Sporidesmium amygdalearum* Pass. f. *amygdali communis*, on *Prunus amygdalus*, Parma, G. Passerini, 1876, Thümen's Mycotheca Univ. No. 1885; *Stigmella platani-racemosae* Dearn. and Barth., on *Platanus racemosa* Nutt., Riverside, CA, E. Bartholemew, 1924, E. Bartholemew Herb. No. 8889, type; *Stigmella platani-racemosae* Dearn. & Barth., on *Platanus racemosa* Nutt., Riverside, CA, 1936, D.J. Smith and C. O. Smith; *Stigmina platani* (Fckl.) Sacc., *Platanus occidentalis* L., Batesville, AR, 1908, E. Bartholemew, E. Bartholemew Herb.; *Stigmella platani* Fckl., on *Platanus occidentalis* L., CA, 1883, H.W. Harkness, Ellis Herb. No. 1224; and *Stigmella platani* Fckl., on *Platanus occidentalis* L., Louisville, KS, E. Bartholemew, 1893, E. Bartholemew Herb. No. 1208.

Specimens from the National Fungus Collections Herbarium were: *Stigmina carpophila* (Lév.) Ellis, on *Prunus persica* L., from Mexico intercepted in Laredo, Texas, 1981, US0427968; *Stigmina pulviniformis* (Syd.) Hughes, on *Rhus* sp., Duquesne, AZ, 1962, US0428020; and *Stigmina*

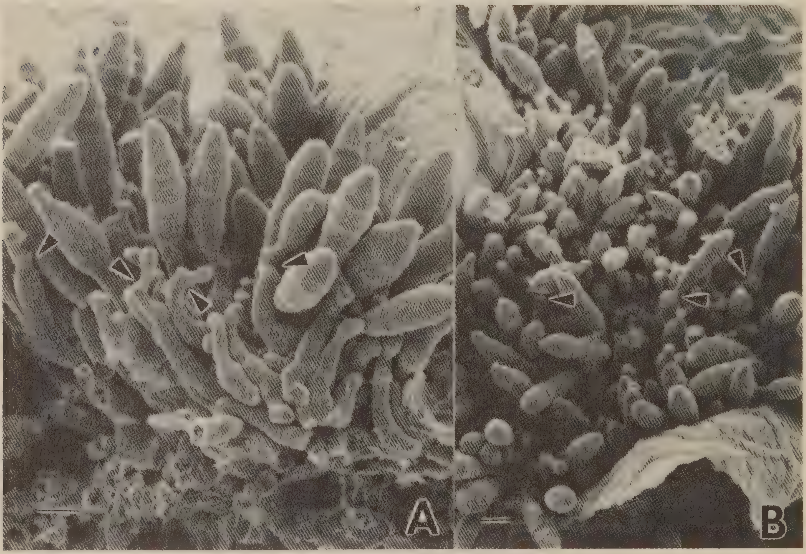


Figure 2. A-B. Scanning electron micrographs of *Wilsonomyces carpophilus* JEA 637 from almond leaf tissue (*Prunus dulcis* var. Nonpareil) inoculated and incubated in a growth chamber. A. Lateral section of a fractured sporodochium (bar = 5 µm) and B. top view of a sporodochium (bar = 10 µm) showing conidia and sympodially developing conidiophores (arrows).

compacta (Sacc.) M. B. Ellis, on *Acer negundo* L., Eden, Utah, C. T. Rogerson, No.1390, US0427970.

Temperature Studies. Cultures of isolates JEA637, JEA797, and JEA798 were grown on malt extract agar (MEA), potato dextrose agar (PDA), or PDA acidified to pH 3.5 with lactic acid (APDA) at 5, 8, 15, 21, 27, 30, and 34 C in the dark. Colony diameter was recorded daily for 4 weeks. Cultures were also grown in the dark for 10 days and then placed under fluorescent lights for a 12-hr period of light each day for 14 days. A cultural description was based on cultures grown on PDA (pH 5.6) at 20 C. Capitalized color names in the description are from Ridgway (1912).

Leaves of potted almond plants were inoculated in growth chambers with isolates JEA637, JEA797, and JEA798. Inoculated trees were given a 16-hr wetness period at 15 C in a dew chamber (Model I-60DL, Percival Manufacturing Co., Boone, Iowa). Leaf surfaces of inoculated plants were allowed to dry for 15 min and plants were transferred to plant growth

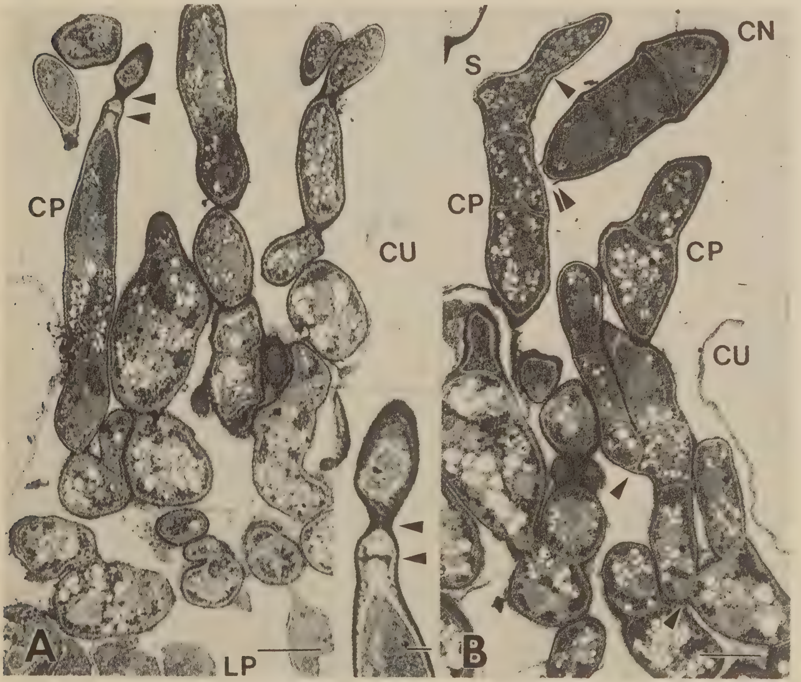


Figure 3. A-B. Transmission electron micrographs of sporodochia of *Wilsonomyces carpophilus* JEA 637. A. Sporodochia forming above leaf palisade (LP) rupturing through host cuticle (CU). Section through a conidiophore (CP) and the base of a conidium. Arrows indicate double septa (bar = 5 µm). Inset. Close-up of double septa (bar = 1 µm). B. Sporodochia rupturing host cuticle (CU) with branching conidiophores (CP) indicated with single arrows. One conidiophore has a scar (S) where a conidium was previously attached. Conidium (CN) with wall-remnants (double arrow) resulting from rhexolysis (bar = 5 µm).

chambers set at 8, 15, and 22 C. Both incandescent and fluorescent lights were timed to provide a 12-hr period of light each day. Additional wetness treatments were applied by spraying plants with distilled water using a hand held spray bottle and covering each plant with a large plastic bag. The plastic bag was sealed for 12 hours while the plants were in the dark. This procedure was repeated every 2 days for 8 days. Leaves were examined for sporodochia 10 days after inoculation.

Microscopy. Fungal material was observed either by bright-field (BF), phase contrast (PC), scanning electron (SEM), or transmission electron microscopy (TEM). For BF and PC microscopy, dry tissue samples were hydrated in 2% potassium hydroxide (KOH) and observed through a Zeiss compound microscope and photographed.

For scanning electron microscopy, fresh tissue was fixed in 2% glutaraldehyde in 0.1 M Sorenson's phosphate buffer (pH = 7.2) for 18-24 hr, washed 3 times in distilled water (5-10 min/wash), post-fixed in 2% osmium tetroxide for 2 hr, washed again, dehydrated in an water-ethanol series (80-20, 50-50, 20-80, 5-95, 5-95, 0-100, 0-100, 0-100) for 5-10 min/treatment, and critical point dried using carbon dioxide. Samples were mounted on SEM stubs, coated with gold to a thickness of 15 nm, observed with an ISI DS-130 SEM, and photographed. Dried herbarium samples were also rehydrated in KOH for 1 hr and processed as previously described. Some leaf samples were dry fractured using forceps after critical point drying.

For transmission electron microscopy, fresh tissue was fixed, post-fixed, and washed as in the SEM preparation, dehydrated in a water/ethanol/propylene oxide series (80/20/0, 50/50/0, 20/80/0, 5/95/0, 0/100/0, 0/50/50, 0/25/75, and 0/0/100) for 3-5 min/treatment, embedded in a Medcast Quik-Mix Epoxy (Ted Pella Inc., Redding CA 96099)/propylene oxide series (30/70, 60/40, 90/10, 100/0, and 100/0) for 1-1.5 hr/treatment with the last treatment overnight, transferred to an embedding mold, fresh resin was added, and samples were polymerized at 60 C overnight. Sections were cut 80-100 nm thick (silver-gray) using a diamond knife in a Sorvall MT-2 microtome (RMC, Tucson, AZ 85745), placed on formvar coated-slotted grids, air dried, stained in 2% uranyl acetate for 30 min, washed in distilled water for 1-2 min, counter-stained in Reynold's lead citrate for 5 min, washed for 1-2 min, and air-dried. Sections were observed using a Zeiss EM 109 TEM and photographed.

RESULTS

Conidial Ontogeny. In culture, development of conidia occurred from 5 to 27 C on MEA, PDA, and APDA. Conidia developed singly and holoblastically from the apex of the conidiogenous cell and from a new growing point that developed laterally and adjacent to the conidial scar. Initially, conidia were subhyaline, fusiform, and continuous with the

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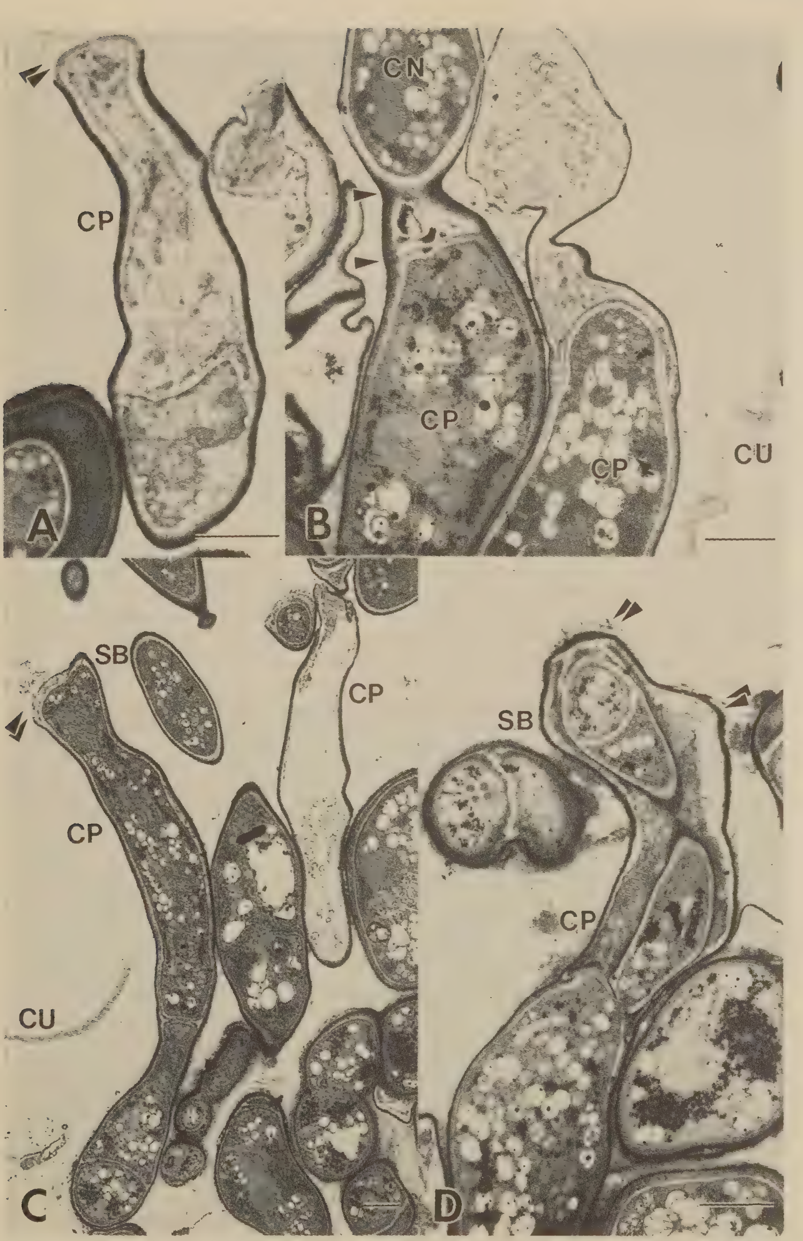
Figure 4. A-D. Transmission electron micrographs of sporodochia of *Wilsonomyces carpophilus* JEA 637 from infected almond leaves inoculated and incubated in a growth chamber (Bars = 2 µm). **A.** Section of conidiophore (CP). Double arrow indicates scar where conidium was previously attached. B. Double septa (arrows) between conidia (CN) and conidiophore (CP). CU = Host cuticle. C and D. Sympodial branches (SB) of conidiophores (CP) in sporodochial tissue. Double arrows indicate scars where single conidia were previously attached. CU = Host cuticle.


CP
A
CN
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CP
CU
B
SB
CP
CP
CU
C
SB
CP
D

conidiogenous cells. Following this stage, a transverse septum delineated the conidiogenous cell from the conidium initial (Fig. 1 A). Conidia continued to enlarge, becoming broadly ellipsoid (Fig. 1 B), while transverse septa formed to delineate individual cells of the conidium (Fig. 1 C). During maturation, a space formed below the basal septum of the conidium and a second transverse septum formed further separating the cytoplasm of the conidiogenous cell from the conidium (Fig. 1 C, inset). At this stage, the conidium was connected to the conidiogenous cell by only an outer wall; eventually, this wall breaks separating the two and completing the rhexolytic process. The conidiogenous cell then proliferated sympodially by producing a lateral branch behind the conidial scar and conidial development was repeated (Fig. 1 A-C). At maturity, conidia were smooth, fusoid, thick-walled, and light brown phragmospores with 3-5 (-7) transverse septa.

Conidiophores of sporodochia from field-collected almond leaves or peach branches showed similar stages of conidial development as observed in cultural studies (Fig. 1 D,E). Conidia were separated by rhexolysis, while the conidiogenous cells developed sympodially. These lateral proliferations of the conidiogenous cell, however, were generally not as elongated as observed in culture (Fig. 1 E).

Examination of conidiophores of sporodochia that formed on almond leaves when plants were inoculated and incubated in growth chambers at 8, 15, and 22 C, also showed sympodial development (Fig. 2 A,B). Conidiophores elongated from branching hyphae in sporodochial tissue (Fig. 3 A,B). After the first transverse septum at the base of the conidium is formed during conidial formation, the cytoplasm recedes, and a second septum is formed creating an inter-cellular space separating the conidium from the conidiogenous cell (Figs. 3 A, 4 B). The clear intercellular area, as observed by bright-field microscopy (Fig. 1), was approximately 1 µm in length, and appeared to contain degenerated cytoplasm when observed using TEM (Fig. 4 B). Upon conidial separation, wall remnants that surrounded the inter-cellular area were observed on the base of the mature conidium (Fig. 3 B). Initially after conidial separation from the conidiogenous cell, conidial scars were less electron dense as compared to the lateral wall of the conidiogenous cell (Fig. 4 A). As the conidiogenous cell developed sympodially, however, scars were more electron dense (Figs. 3 B, 4 C,D).

Morphology of Conidia and Conidiophores in Herbarium Collections. Conidia and conidiophores of herbarium samples of *Sporidesmium amygdalearum* (type material) and collections of other synonyms of *Stigmina carpophila*, were similar in morphology with collections of the fungus made in California. Morphological evidence for rhexolytic development was observed as wall fragments or remnants of the inter-cell that separated the conidium from the conidiogenous cell (Fig. 5 A, B). These fragments were attached to the conidial scar of the conidiogenous cell or to the basal septum of the conidium. Further, conidiogenous cells were observed as sympodulophores in larger, presumably older sporodochia (Fig. 6 A-D).

Conidia, conidiophores, and sporodochia were examined in collections of: *Stigmina platani-racemosae* including the type specimen, *S. platani*, *S. compacta*, and *S. pulviniformis*. Based on these observations, ontogeny and morphology of conidia, as well as morphology of conidiophores were distinct from those of *S. carpophila*. These fungi had sporodochia associated with stomata and produced conidia singly at the apex of the conidiophore with subsequent conidial formation by percurrent proliferation of the conidiogenous cell through the conidial scar. This resulted in annellations or rings around the apex of the conidiogenous cell or annellide (Figs. 6 E-I, 7 A-D). No evidence of conidial separation by rhexolysis was observed. Further, the surface of the conidia of these fungi was densely verrucose or roughly encrusted at maturity (Fig. 7 A-D).

Based on the evidence presented above a new genus is proposed:

WILSONOMYCES Adaskaveg, Ogawa, and Butler gen. nov.

Latin Description: *Conidiophora dense compaginata, primo brevia deinde paniculata sympodice, rami cellâ conidiiferâ terminati, transeuntes septati, evoluti in stromatibus compactis sporodochia formantes; conidia crassitunicata, solitaria, holoblastica, et terminalia, cum septis transversis aliquando obliquis, raro longitudinalibus, subhyalina ad brunea, atra (olivacea ad nigra) in massa, rhexolytica secedens.*
Type Species: *Helminthosporium carpophilum* Lév., Ann. Sci. Nat., Ser. 2, 19, description p. 215, Plate 7, Fig. 5. Typotype of the fungus collected by J. H. Léveillé is no longer at the Muséum National d'Histoire Naturelle, Paris as part of Léveillé's or Montagne's Herbaria.
Etymology: Named for E.E. Wilson, late professor of plant pathology, University of California, Davis, whose research, over many years, contributed to the understanding and control of diseases of fruit and nut crops including shot hole of *Prunus* species.

WILSONOMYCES CARPOPHILUS (Lév.) Adaskaveg, Ogawa, and Butler, comb. nov. Basionym: *Helminthosporium carpophilum* Lév., Ann. Sci. nat., Ser. 2, 19, p. 215, Plate 7, Fig. 5. 1843. Synonyms: *Macrosporium rhabdiferum* Berk., Gdnr's Chron. p. 938, 1864; *Sporidesmium amygdalearum* Pass., Boll. Com.

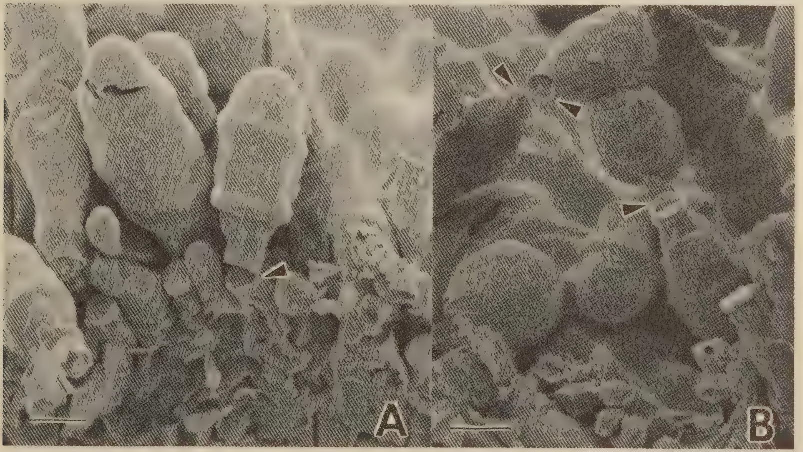

Figure 5. A-B. *Sporidesmium amygdalearum* No. 474. de Thumen's Mycotheca Universalis. Bar = 5 µm. A. Conidia and conidiophores from a fractured, young sporodochium. Arrow indicates rhexolytic separation. B. Basal septa of several conidia with remnants of wall material from the conidiogenous cell (arrows).

Agr. Parma, 1875; *Clasterosporium amygdalearum* (Pass.) Sacc., Michelia 2:557, 1880; *Coryneum beyerinckii* Oudemans, Hedwigia 22:115, 1883; *Coryneum laurocerasi* Prillieux et Delacroix, Bull. Soc. Mycol. Fr. 6:179, 1890; *Clasterosporium carpophilum* (Lév.) Aderhold, Landw. Jb. 30:815, 1901; *Coryneum carpophilum* (Lév.) Jauch, Int. Bull. Pl. Prot. 14:99, 1940; *Stigmina carpophila* (Lév.) M.B. Ellis, Mycol. Pap. 72:36-71, 1959; *Sciniatosporium carpophilum* (Lév.) Morgan-Jones, Canad. J. Bot. 49: 993-1009 (see Sutton, 1972).

Morphology of Fungus on Host Tissue

Sporodochia usually punctiform, tan to olivaceous-brown then black, parasitic on species of *Prunus* and occurring on leaves, twigs, flowers, and fruit.

Mycelium mostly immersed in plant tissue, occasionally partly superficial, septate, smooth-walled, branching, 2-6 µm in diam, initially sub-hyaline becoming light brown.

Stroma present, compact, immersed, erumpent, discoid on leaves, 30-300 µm in diam, fusoid on twigs, 30-200 µm long.

Setae and hyphopodia absent.

Conidiophores macronematous, mononematous, packed together forming pulvinate sporodochia, straight or flexuous, initially unbranched then branched sympodially, forming a sympodulophore, cylindrical to lageniform, geniculate, smooth, 10-45 X 3-12 µm, subhyaline to tan, cicatrized, scars inconspicuous to conspicuous.

Conidia solitary, dry, acrogenous, simple, thick-walled, cylindrical, clavate, ellipsoidal or fusiform, occasionally forked, rounded to acute at the apex, truncate at the base, generally 3 to 5 (2-10) transverse with occasionally 1-2 oblique septa, rarely with 1 longitudinal septum, 20-90 µm long, 7-16 µm in diam at the widest point, 3.5-6 µm at the base, subhyaline to golden brown, dark olivaceous to black in mass. Conidium divided from conidiogenous cell by double wall septum, conidial separation by rhexolysis.

Cultural Characteristics

Macroscopic: Growth moderate, PDA plates covered in 4 weeks; advancing zone diffuse, even to bayed, mostly consisting of submerged hyphae with sparse aerial mycelium forming 2-3 mm behind margin; in 2-3 week-old cultures grown in the dark, submerged subhyaline hyphae radiate outward from dense mycelial mat, aerial mycelia sub-felty to felty initially White becoming Pale Olive-Gray to Grayish-Olive occasionally

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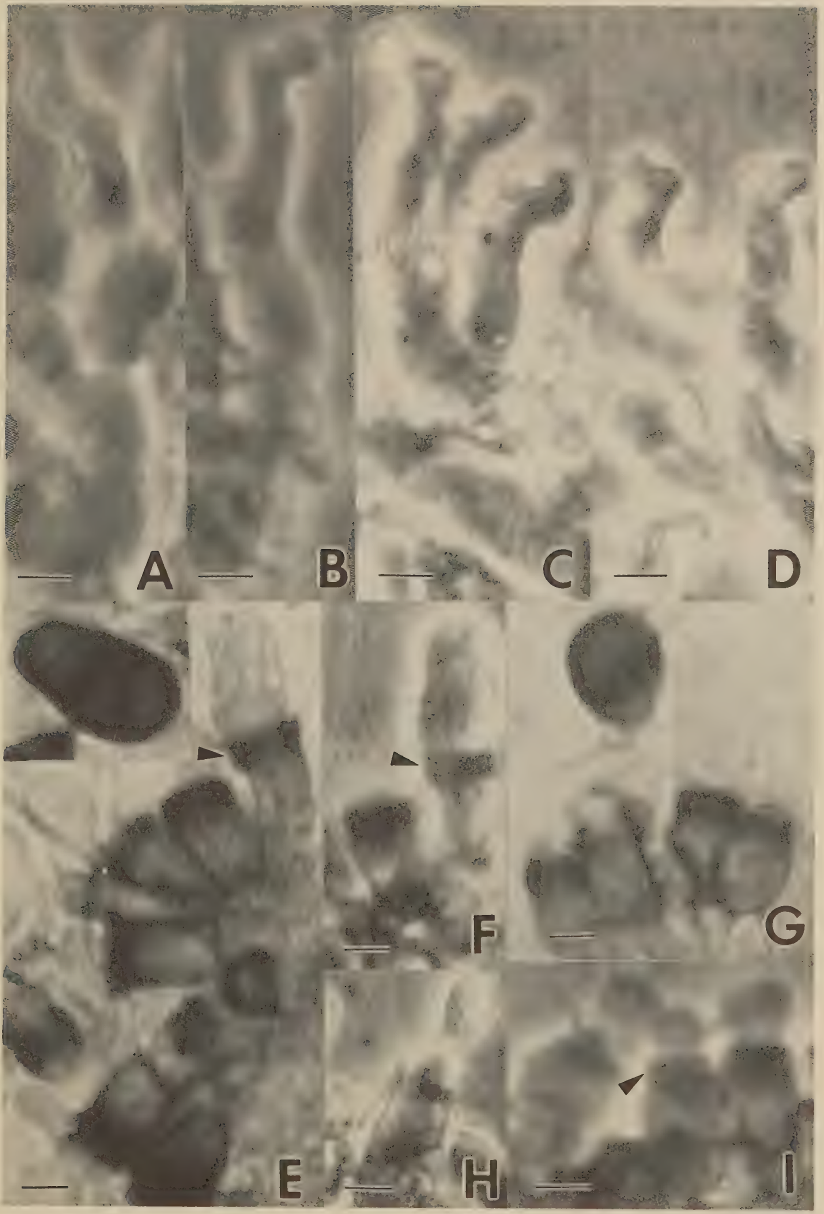
Figure 6. **A-I.** Phase contrast and bright-field micrographs of conidiophores of *Sporidesmium amygdalearum* No. 474. de Thumen's Mycotheca Universalis, *Stigmella platani-racemosae* No. 8889. E. Bartholemew Herbarium (type specimen), and *Stigmella platani* No. 1224. Dr. H.W. Harkness collection. Bars = 5 µm. **A-D.** Phase contrast micrographs of conidiophores of *S. amygdalearum* showing sympodial development. **E-H.** Conidia and conidiophores of *Stigmella platani-racemosae* showing percurrent development of annellides (arrows indicate annellations). **E and G.** Bright-field micrographs. Inset. Mature spore. **F and H.** Phase contrast micrographs of late and early conidial development, respectively. and I. Phase contrast micrograph of *Stigmella platani* showing percurrent development of annellide (arrow indicates annellation).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Olive-Ochre. In cultures exposed to light, submerged Light Brownish Olive to Olive-Brown hyphae radiate outward from mycelial mat; aerial hyphae Buffy-Brown; Olivaceous-Black to Black spores produced in mass; reverse Olivaceous-Black to Black under mat with a Light Brownish Olive border fading to a hyaline margin; cultures become zonate when exposed to alternating light and dark cycles. Optimum temperature range 15-21 C on PDA, growth rate 2-3 mm/day. No growth below 5 C or above 30 C.

Microscopic: Hyphae of advancing zone septate, thin-walled, branched 3-9 µm diam, subhyaline to light brown. Older hyphae light brown to brown, forming a pseudoparenchyma of swollen hyphal cells, 10-20 X 20-30 µm. Conidiophores simple to irregularly branched, 5-8 µm in diam, proliferating sympodially from the apex, cicatrized, subhyaline to light brown. Conidia fusoid with apical cell ovate and basal cell truncate, 20-45 (-65) µm X 12-16 (-18) µm, 3-7 celled with 2-6 transverse septa occasionally with an oblique septum, light brown to brown.

Cultures examined: JEA637, JEA770, JEA797, JEA798, JEA1350, and JEA1351.

Remarks: This cultural description is similar to that of Matsushima (1975) with added information of growth habit, rate, temperature parameters, and hyphal morphology.

DISCUSSION

The conidiogenous cells of *W. carpophilus* developed sympodially in culture and in both recently collected plant material and herbarium samples examined. This characteristic has been described as geniculate (Samuel 1927) and included in drawings by numerous researchers, including Samuel (1927), Berkeley (1864), and Léveillé (1843). In Léveillé's original description, his simple drawing shows conidiophores with sporulating, lateral branches that arise singly from beneath another conidium or conidial scar. We attempted to examine the typotype or other collections of Léveillé labeled *H. carpophilum.* Searches were made for them in several herbaria in Europe, but they were not found. Stafleu and Cowan (1976) indicated that Léveillé's herbarium had been destroyed in the Franco-Prussian War in 1870-1871, although some duplicates of his collections of other fungi have been found in several herbaria. Since Léveillé's collections of the fungus could not be examined, we selected his drawing as the lectotype.

Wilsonomyces carpophilus consistently produced sympodulophores under various environmental conditions in culture and in plant material from either growth chamber studies or field collections. Although some annelledic fungi, such as species of *Deightoniella* (Pollack and Matthews 1976), *Leptographium, Verticicladiella* (Wingfield, 1985), and species in the Diatrypaceae (Glawe and Rogers 1984) have been shown to produce a sympodially branching conidiogenous cell from an annellide, other fungi like species of *Cercospora* and *Sympodiella* consistently produce conidia from a sympodulophore. In our study of *W. carpophilus*, we observed only sympodially developing conidiogenous cells. Furthermore, separation of conidia in *W. carpophilus* was not by schizolysis, which is typical of annellidic fungi (Cole 1986). Instead, conidia separated from conidiogenous cells by a process consistent with rhexolysis as described by Hughes (1971) and Cole (1986). Ellis (1959) recognized that the conidiogenous cell develops sympodially, however, he may have misinterpreted the rhexolytic process of conidial separation as annellidic development.

For the cultural description, optimal conditions for cultural growth were selected. Jauch (1940) indicated an optimum temperature of 21 C for linear growth using potato-glucose agar (pH=6.0) with no growth at 4 or 34 C. Shukla and Bhat (1984), in comparing temperature, media, and pH, indicated that the optimal conditions for growth were at 20 C using PDA (pH 5.5). In a study to determine optimum nutrient, temperature, and pH, Williams and Helton (1971) indicated an optimal temperature range of 15-20 C and pH 5.4-5.8 when ß-maltose/L-asparagine or D-glucose/L-proline were used for the carbon/nitrogen sources. Using PDA (pH 5.5), we determined an optimal temperature range of 15-22 C with no growth below 5 C or above 30 C. Although cultural sectors differing in conidial production were reported by Samuel (1927), this was not a

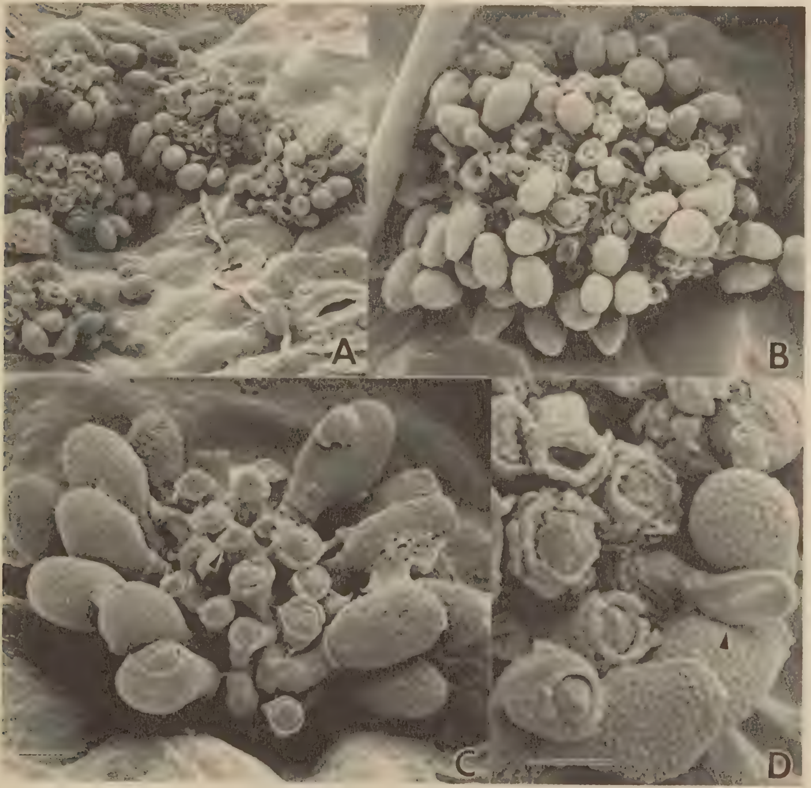

Figure 7. A-D. Scanning electron micrographs of *Stigmella platani* No. 1224. Dr. H.W. Harkness collection. and *Stigmella platani-racemosae* No. 8889. E. Bartholemew Herbarium (type specimen). Bars = 5 µm. Sporodochia commonly associated with stomata. A and C. Sporodochia of *Stigmella platani* (arrow indicates annellation). B and D. Sporodochia of *Stigmella platani-racemosae* (arrow indicates percurrent development of immature conidium).

character of our cultures on any of the media studied and was not included in the description.

Ideally, we would like to base our taxonomy of fungi on the holomorph. Although the teleomorph of some species in the form genus *Stigmina* has been placed in the genus *Mycosphaerella* Johanson (Barr 1972) or in the genus *Otthia* Nits. (von Arx and Müller 1975), the teleomorph of *W. carpophilus* is unknown. Currently, the generic concept of the genus *Stigmina* includes over 85 species that have been described from leaves, stems, bark, and wood of a wide variety of hosts including herbaceous plants, palms, conifers, and deciduous hardwoods. Sutton and Pascoe (1989) recognized the heterogenous nature of the genus and tentatively placed species of the genus into 3 groups based on their morphology of conidia and conidiogenous cells and pathology. They considered species of the first group, *Stigmina sensu stricto*, similar to the lectotype of the genus, *S. platani*. Further, they considered these fungi as foliicolous, with effuse or sporodochial conidiomata associated with stomata, while holoblastic, distoseptate, brown conidia formed from verruculose annellides with ragged annellations. Species of their second group, which included *S. carpophila* and *S. compacta*, were characterized by pulvinate sporodochia not associated with stomata and were found on leaves, stems, and branches of hosts. Pale brown conidia were considered holoblastic, euseptate, and formed from smooth annellides. Species comprising the third group could not be placed into recognizable categories due to their markedly different conidial morphology. Additionally, Sutton and Pascoe emended the genus *Stigmina* and included schizolytic succession of conidia. Their contention for future revisions of the genus was to reduce the heterogeneity of the genus and they suggested the possible resurrection of the generic synonym, *Thyrostroma* Höhnel, for the second group. We agree with Sutton and Pascoe (1989) that the genus *Stigmina* is heterogenous and that *S. carpophila* is distinct from *S. platani* (*Stigmina sensu stricto* group). Based on the information from our study, however, the genus *Thyrostroma* would be inappropriate since conidia of the species *T. compactum* (Sacc.) Höhnel develop percurrently from annellides (Ellis 1959) and this was confirmed in the specimen we examined.

We also considered transferring *S. carpophila* into the genus *Thyrostromella* Höhnel as redescribed by Hughes (1955). In the type species, *T. myriana* (Desm.) Höhnel, holoblastic conidia separate rhexolytically and conidiogenous cells develop sympodially (Hughes 1955). Since this fungus occurs on European beachgrass (*Ammophila arenaria* (L.) Link) and its spores were dictyospores, the genus was not considered suitable. No other species is described with sporodochial conidiomata, rhexolytic separation of conidia, sympodially developing conidiogenous cells, and smooth walled, phaeophragmospores. Thus, the genus *Wilsonomyces* is described based on the species *W. carpophilus*.

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KEY WORDS

Fungi Imperfecti, Deuteromycotina, Leaf Spot Diseases, *Coryneum beyerinckii, Coryneum carpophilum, Clasterosporium carpophilum, Stigmina carpophila.*

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MYCOTAXON

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EXOPHIALA JEANSELMEI VAR. *CASTELLANII*, A NEW COMBINATION FOR *EXOPHIALA CASTELLANII*

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In 1984, Iwatsu et al. (2) described *Exophiala castellanii* Iwatsu, Nishimura et Miyaji to accommodate the strain CBS 158.58 [received as *Exophiala mansonii* (Castell.) de Hoog]. *Exophiala castellanii* is unique because of its restricted growth and colony appearance compared with allied species of *Exophiala* Carmichael. Colonies of *E. castellanii* reach a diameter of less than 6 mm after incubation for 14 days at 27°C on Sabouraud's dextrose agar. In old cultures on Sabouraud's dextrose agar or potato dextrose agar, the colonies of *E. castellanii* are wrinkled, giving a brain-like appearance. Except for these two differences, *E. castellanii* is not distinguishable from *E. jeanselmei* (Langer.) McGinnis et Padhye (6). In 1977, de Hoog (1) classified *E. jeanselmei* into three varieties; var. *jeanselmei*, var. *heteromorpha* (Nannf.) de Hoog and var. *lecanii-corni* (Benedek et Specht) de Hoog. Recent chemotaxonomical data (3, 4, 5) also pointed out that *E. jeanselmei* is an extremely heterogenous assemblage. Considering that the differences between *E. castellanii* and *E. jeanselmei* are not large and *E. jeanselmei* is a species containing diverse entities, it is our present view that *E. castellanii* is better placed as the fourth variety to *E. jeanselmei*. Therefore, the following new combination is proposed.

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* To whom correspondence should be addressed.

Exophiala jeanselmei (Langer.) McGinnis et Padhye var. *castellanii* (Iwatsu, Nishimura et Miyaji) Iwatsu et Udagawa, comb. nov.

≡ *Exophiala castellanii* Iwatsu, Nishimura et Miyaji, Mycotaxon 20: 307, 1984.

= *Rhinocladiella mansonii* (Castell.) Schol-Schwarz sensu Schol-Schwarz, Antonie van Leeuwenhoek 34: 122, 1968, pro parte; non *Microsporum mansonii* (as *Microsporon mansoni*) Castell., Brit. Med. J. 2: 1271, 1905, nomen dubium.

= *Exophiala mansonii* (Castell.) de Hoog sensu de Hoog, Stud. Mycol. 15: 114, 1977, pro parte; non *Microsporum mansonii* (as *Microsporon mansoni*) Castell., Brit. Med. J. 2: 1271, 1905, nomen dubium.

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Albino Spores Associated with Dark-spored Species of *Scutellispora*.

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SUMMARY

The occurrence of albino (white) spores, first noted for *Scutellispora nigra* in 1979, are reported for the first time in pot cultures of *S. heterogama* and *S. gregaria.* No cultures from any of the above species could be re–established from albino spores.

Key Words: VA mycorrhizal fungi, Endogonaceae

In the literature of the Endogonaceae, there are many reports on different spore types and spore variations which can occur during the life cycle of a single species. Two types of spores formed by one species were reported for the dimorphic species *Glomus ambisporum* and *G. heterosporum* (Smith and Schenck, 1985) and *G. dimorphicum* (Boyetchko and Tewari, 1986). Aborted chlamydospores together with normal ones were found in *Glomus vesiculiferum* and in *G. canadense* (Thaxter, 1922). In *Gigaspora decipiens* (Hall and Abbott, 1984) the azygospores exhibit great variability in wall structure and color during their development. The flesh–colored spores produced in pot culture by *Scutellispora verrucosa*, a species with brown–colored spores with roughened walls, can appear almost white (Koske and Walker, 1985). Morton (1988) analyzed variation in spore color within species in the Endogonaceae. He observed that taxa which formed white (translucent) or hyaline (transparent) spores rarely had spore colors darker than a pale brown. *Glomus fecundisporum* was the only exception in the literature, being described as occasionally forming brown to black spores in culture (Schenck and Smith, 1982). Spores which are yellow or yellow brown at their lightest, including *Scutellispora heterogama*, darken at most to an orange–brown or red–brown color.

The first report in the literature of albino (white) spores was with *S. nigra* (Nicolson and Schenck, 1979). Since this occurrence was included in the description of *S. nigra*, it frequently has been overlooked. The purpose of this paper is to reiterate the original occurrence of albino spores in *S. nigra* and extend the occurrence of albino spores to two additional dark–spored species of *Scutellispora.*

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In our study we found albino spores consistently associated with the brown spores of *Scutellispora heterogama*, in isolates #139 and #964 of the International Culture Collection of VA Mycorrhizal Fungi (INVAM). They were recovered also from a field soil sample collected near Gainesville, Florida. *Scutellispora heterogama* isto form light brown spores (Nicolson and Gerdemann, 1968) or spores pale–yellow brown to red brown with four walls arranged in two wall groups (Koske and Walker, 1985). The outer wall group A contains an outer ornamented, pale yellow to yellow–brown unit wall tightly adherent to an inner laminated, yellow–brown wall. Wall group B consists of two hyaline membranous walls.

The albino spores were white, some with a pale yellow tint, mostly globose, 140–220 um diam. (Fig. 1). They had the same size and the same wall structure as mature brown spores of *S. heterogama*, except for the brown color. They had an outer unit, hyaline, ornamented wall, a hyaline laminate wall and 1 or 2 hyaline membranous walls. Brown spores of *S. heterogama* collected near Gainesville reproduced the albino spores in low percentage in pot culture. We were unsuccessful in establishing a pot culture from the albino spores alone. The repeated failure to establish pot cultures from albino spores also occurred with of *S. nigra* (Nicolson and Schenck, 1979) and with INVAM isolate #223 of *S. gregaria* (Y. Pérez, personal communication).

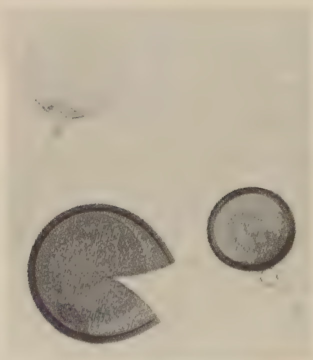

Fig. 1. Albino spore (upper) and normally–tinted spores (lower) *of Scutellispora heterogama.*

Fungi producing albino spores not only lose spore color but concomitantly lose their ability to establish mycorrhizae with these spores. Thus, isolates of fungi producing albino spores could reduce their competitiveness in nature in proportion to the number of albino spores they produce.

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MYCOTAXON

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NEW OR INTERESTING LICHENICOLOUS FUNGI

1. SPECIES FROM LUXEMBOURG

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Abstract: Three new genera of lichenicolous fungi are described: *Lawalreea lecanorae* Diederich gen. et sp. nov. (Coelomycetes), *Marchandiomyces corallinus* (Roberge) Diederich & D. Hawksw. gen. et comb. nov. to accomodate the hyphomycete previously known as *Illosporium corallinum*, and *Feltgeniomyces luxemburgensis* Diederich gen. et sp. nov. (Hyphomycetes). Descriptions of 7 other new species are given: *Abrothallus acetabuli* Diederich, *Bispora lichenum* Diederich, *Polycoccum tinantii* Diederich, *Pyrenochaeta xanthoriae* Diederich, *Sclerococcum epiphytorum* Diederich, *Taeniolella chrysothricis* Diederich and *T. trapeliopseos* Diederich. The new combination *Abrothallus prodiens* (Harm.) Diederich & Hafellner (= *Lecidea prodiens*) is introduced. Discussions on the systematic position of *Leptosphaeria ramalinae* and on the conidiogenesis of *Phaeosporobolus usneae* are presented.

The lichenicolous fungi represent one of the least explored groups of fungi, and only in the last 10-15 years have modern taxonomic works started to appear. The most important mycologists having recently studied lichenicolous fungi are J. Hafellner, D. L. Hawksworth and R. Santesson. The lichenicolous deuteromycetes have been reviewed by Hawksworth (1979, 1981), but only a small number of genera belonging to the ascomycetes have been the object of modern revisions. An uncritical compilation of almost all known species with determination keys has recently been published (Clauzade, Diederich & Roux, 1989). My study of large collections of lichenicolous fungi shows that about 20 percent of European specimens, and more than 50 percent of extra-European specimens cannot be determined with these keys; they most probably represent undescribed or uncatalogued species. The present series of papers will discuss new, interesting or poorly known lichenicolous fungi. This first part is restricted to taxa growing on epiphytic lichens in the Grand Duchy of Luxembourg. Subsequent parts will mainly deal with other European and extra-European species.

Abrothallus acetabuli Diederich **sp. nov.** (Fig. 1)

Fungus lichenicola. Ascomata apothecia, superficialia, convexa, ad basim valde constricta, epruinosa vel leviter pruinosa in statu juvenili, (0.15)0.27-0.47(0.65) mm diam. Hymenium hyalinum ad pallide brunneum, K-; epihymenium et hypothecium atrobrunnea. Asci 8-spori. Ascosporae brunneae, verruculosae, 1-septatae, (12.5)13.5-15(16) x 5.5-6.5(8) µm. Pycnidia 100-200 µm diam., atra, partim immersa, ostiolata. Paries 25-30 µm crassus. Conidiophora desunt. Cellulae conidiogenae holoblasticae, hyalinae. Conidia hyalina, obpyriformia ad ellipsoidea, non septata, basi truncata, subtiliter verrucosa, (6.3)7-8.5(9) x (4)4.5-5.0 µm.

Typus: Luxemburgum, Mersch, in thallo *Parmeliae acetabuli* ad *Fraxinum*, 9 x 1984, Diederich 5860 (LG: holotypus; herb. Diederich: isotypus).

Mycelium immersed in the host thallus, I-. Apothecia frequent, superficial, convex, strongly constricted at the base and often shortly stipitate, black, epruinose or scarcely pruinose when young, (0.15)0.27-0.47(0.65) mm diam. (n = 219). Hymenium hyaline to brownish, K-; epihymenium covert by a dark brown crystalline layer dissolving in KOH into a yellow substance; hypothecium brown, K-. Asci 8-spored. Ascospores brown, verruculose, 1-septate, the 2 cells being slightly unequal, (12.5)13.5-15(16) x 5.5-6.5(8) µm; ratio length:width (2)2.2-2.6(3) (n = 35). Pycnidia infrequent, 100-200 µm diam., black, partly immersed, with a distinct ostiole. Wall subhyaline to brownish in the lower part and brown to dark brown in the upper part, K-, 25-30 µm thick. Conidiophores absent. Conidiogenous cells holoblastic, lining the pycnidial cavity, hyaline. Conidia hyaline to yellowish, obpyriform to ellipsoid, collecting in a mucilaginous mass, simple, distinctly truncated at the base, with a finely verrucose surface, (6.3)7-8.5(9) x (4)4.5-5.0 µm; ratio length:width (1.3)1.4-1.9(2) (n = 30).

Host: *Parmelia acetabulum* (commensalistic on thallus and apothecia). That *Abrothallus acetabuli* is restricted, amongst the brown *Parmelia* species, to *Parmelia acetabulum*, supports the opinion of Lumbsch, Kothe & Elix (1988) that *Parmelia acetabulum* does not belong to the genus *Melanelia* (= *Parmelia* subgen. *Melanelia*), and that a separate genus (*Pleurosticta* Petrak) is needed to accomodate the *Parmelia acetabulum*-group.

Distribution: I have collected this species in France, Germany and Luxembourg. In addition, *Abrothallus parmeliarum* (Sommerf.) Arnold s.l. has been mentioned on *Parmelia acetabulum* by Brand & al. (1988: 18) from the Netherlands; the corresponding specimens most probably belong to *A. acetabuli*.

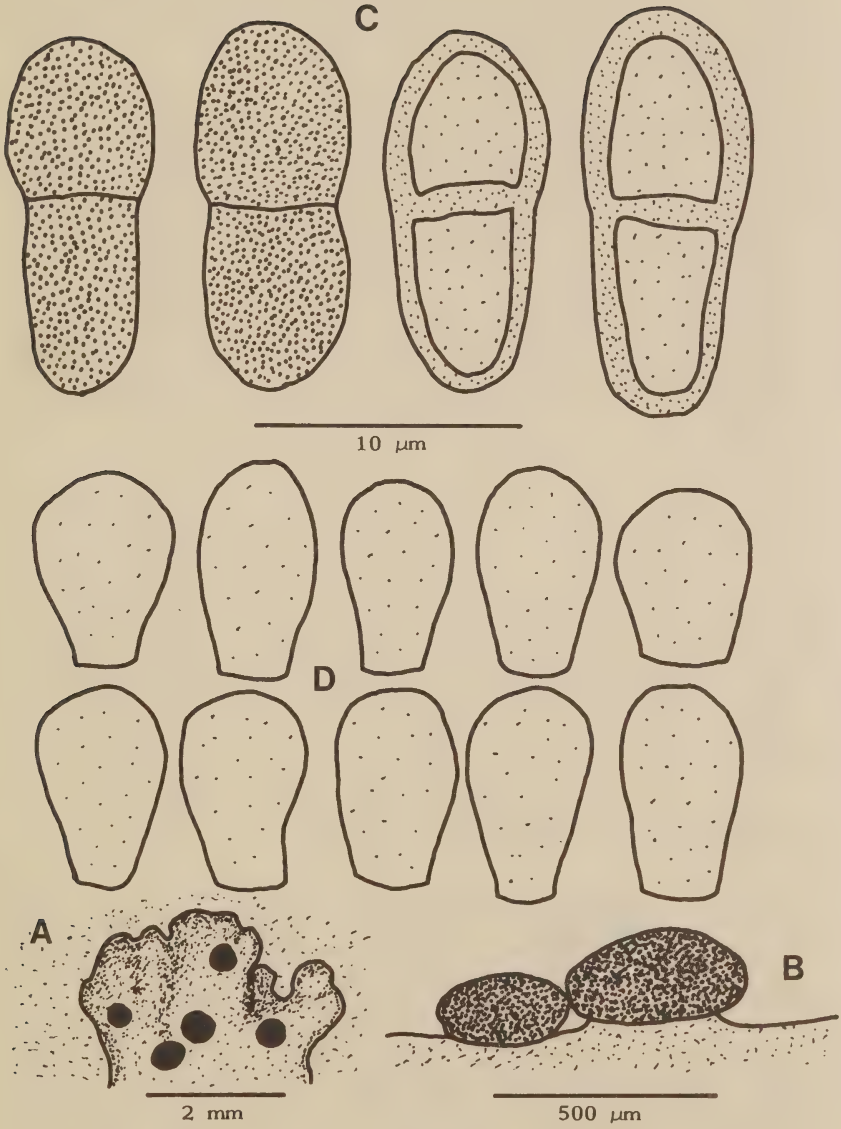
C
10 μm
D
A
2 mm
B
500 μm

Fig. 1. - *Abrothallus acetabuli* (LG - holotype): A, Thallus of *Parmelia acetabulum* with ascomata. B, Ascomata. C, Ascospores. D, Conidia.

Observations: *A. acetabuli* is easily distinguished from the other species of its genus by the hymenium and epihymenium not reacting in KOH, the rather large apothecia, the dimensions of the ascospores and conidia, the mycelium not reacting in iodine, and the different host.

Additional specimens (all on *Parmelia acetabulum*): France, Dept. Mayenne: Parc Naturel Régional Normandie-Maine, near Alençon, Chapelle Sainte-Anne N of Champfrémont, on *Fagus*, 10 vi 1980, Hafellner 8734 (herb. Hafellner). Dept. Meuse: Damvillers, Côte de Morimont, on *Pyrus*, 7 ix 1980, Diederich 6790 (herb. Diederich). - Germany, Sarre: NE Beckingen, on *Malus*, 1 vii 1984, Diederich 5767 (herb. Diederich). - Luxembourg: Rambrouch, on *Fraxinus*, 14 ix 1979, Diederich 6378 (herb. Diederich). SE Beckerich, on *Tilia*, 14 ix 1979, Diederich 6788 (herb. Diederich). S Nagem, on *Tilia*, 14 ix 1979, Diederich 1810 (herb. Diederich). E Eppeldorf, on *Pyrus*, 23 vii 1980, Diederich 6789 (herb. Diederich). W Beckerich, on *Acer*, 20 iv 1985, Diederich 6003 (herb. Diederich). W Remich, N Reckingerhof, on *Fraxinus*, 25.5.1985, Diederich 6099 (herb. Diederich). Niederanven, Aarnescht, on *Pyrus*, 25 viii 1985, Diederich 6646 (herb. Diederich). Lintgen, on *Pyrus*, iii 1986, Diederich 6853 (herb. Diederich).

Abrothallus prodiens (Harm.) Diederich & Hafellner **comb. nov.** (Fig. 2)

Basionym: *Lecidea prodiens* Harm., *Bull. Soc. Sci. Nancy* **31**: 115 (1898).

Buellia prodiens (Harm.) H. Olivier, *Bull. Acad. intern. Geogr. botan.* **15**: 281 (1905).

Abrothallus parmeliarum f. *prodiens* (Harm.) Vouaux, *Bull. Soc. mycol. France* **29**: 467 (1913).

Typus: France, s. ref. [probably: Docelles, V. & H. Claudel, Harmand], on *Hypogymnia physodes*, < 1900 (ANGUC, holotypus).

Mycelium not reacting with iodine. Apothecia superficial to substipitate, black, epruinose or with a dark scarcely visible pruina, (0.1)0.15-0.25(0.35) mm (n = 51). Hymenium brownish, K+ green in the upper part and K- in the lower part; epihymenium covered by a reddish brown to dark olivaceous crystalline layer, presenting the same reaction with KOH as the hymenium, but liberating in addition a yellow solution; hypothecium dark reddish brown, K- (or K+ yellowish). Lower part of the apothecia composed of brown isodiametric or elongated sometimes branched cells. Paraphyses hyaline, branched, not thickened at the apex, 1.7-2.3 µm diam. Asci 8-spored. Ascospores at first olivaceous, then brown, with a verrucose surface, 1-septate, with slightly unequal cells, distinctly restricted at the septum, (10.5)12-14.5(16.5) x (4.5)5.5-6.5(7) µm; ratio length:width (1.8)2-2.5(3.2) (n = 122). Anamorph generally absent (see below).

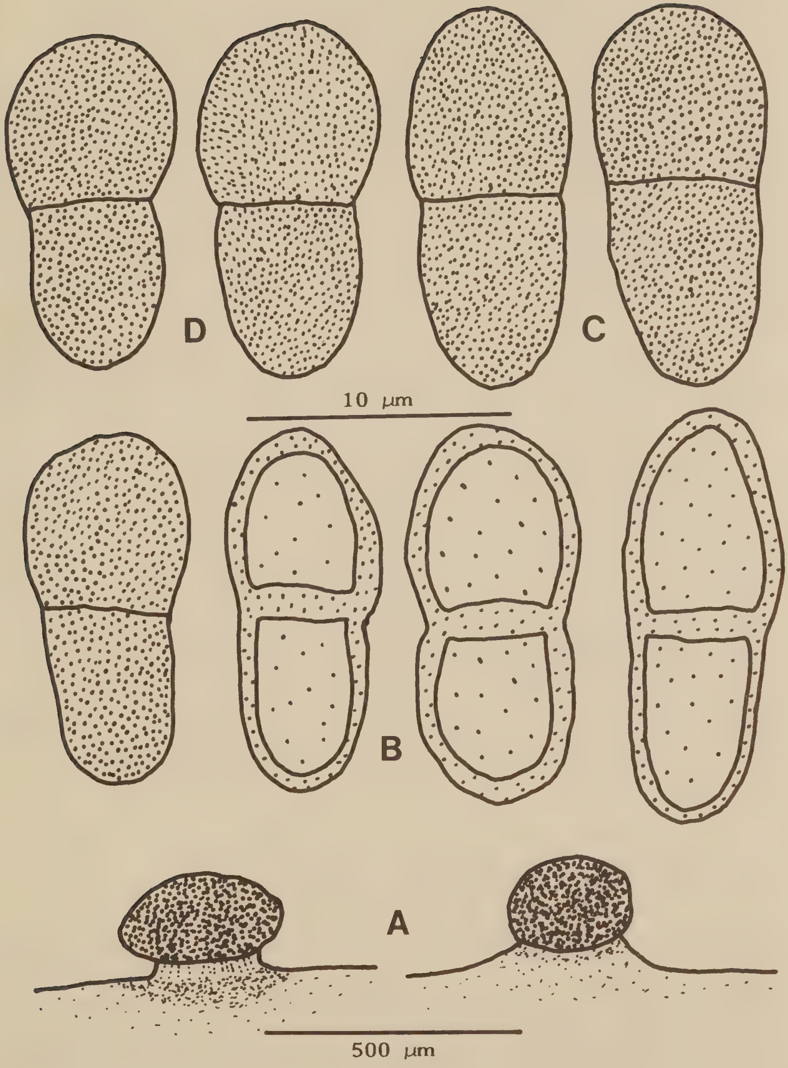
D
C
10 μm
B
A
500 μm

Fig. 2. - *Abrothallus prodiens* (A, B: ANGUC - holotype; C: ANGUC - Bitche; D: Diederich 5360): A, Ascomata. B-D, Ascospores.

Host: *Hypogymnia physodes*. The apothecia often grow on black spots of the host that are not due to this fungus.

Distribution: Austria, France, Germany, Great Britain and Luxembourg.

Observations: The original description of this species was incomplete as no measurements were given. Harmand (1898) stated that the apothecia were black, epruinose, and superficial to substipitate at maturity. The hyaline paraphyses mentioned by Harmand are difficult to study as the epihymenium is covered by a dark crystalline layer.

In a German specimen of *Abrothallus parmeliarum* s.l. on *H. physodes* I found no apothecia, and most pycnidia belong to the lichen. In a few old pycnidia I found some conidia characteristic of *Vouauxiomyces*, the anamorph of *Abrothallus*. They were much smaller than the conidia of *A. parmeliarum*, but a detailed analysis of them was not possible.

A. prodiens is distinguished from *A. parmeliarum* s.s. by the brownish hymenium (instead of hyaline to greenish), the substipitate apothecia at maturity, the smaller conidia, and the different host (*A. parmeliarum* grows on *Parmelia* s.s.).

Additional specimens (all on *Hypogymnia physodes*): Austria, Steiermark: Grazer Bergland, Moor auf der Teichalpe bei Fladnitz, zwischen Königshütte und Harrerhütte, 3 vi 1978, Philippek s. n. (herb. Hafellner 9877). Hochschwab-Gruppe, Tragößtal, Weg Richtung Pfarreralm, ca. 2.5 km NW Oberort-Tragöß, on Larix, 14 ix 1986, Sitzwohl & Obermayer s. n. (GZU). - France, Dept. Moselle: Bitche, 1890, Kieffer s.n. (ANGUC). Dept. Sarthe: Parc Naturel Régional Normandie-Maine, Forêt de Sillé NW of Mans, Saut du Serf SW of Montreuil-le-Chétif, Quartzitblockwerk mit einzelnen Eichen, 8 vii 1980, Hafellner 8900 (herb. Hafellner). - Germany, Rheinland-Pfalz: Entre Gerolstein et Prüm, S Schwirzheimer Kopf, iv 1985, Follmann s.n. (herb. Diederich). - Great Britain, Scotland, VC 106: East Ross, Morrich More, ENE of Loch Preas an Uisge, on *Calluna*, 29 viii 1987, Coppins 11806 (E). - Luxembourg: W Hoffelt, dans l'ancien canal Meuse-Moselle, on *Salix*, 24 viii 1980, Diederich 5360 (herb. Diederich).

Bispora lichenum Diederich **sp. nov.** (Fig. 3)

Fungus lichenicola. Mycelium immersum in lichenum hymenio, ex hyphis pallide brunneis plerumque 1 µm latis. Conidiophora semi-macronemata, mononemata, ramosa, pallide brunnea, levia, septata, septis distincte restricta, 25-50 µm longa et 1.7-3 µm lata. Cellulae conidiogenae monoblasticae vel rarissimo polyblasticae, integratae, terminales, subcylindricae ad ellipsoideae, pallide brunneae. Conidia subglobosa ad ellipsoidea, pallide brunnea, non septata, levia, catenata, catenis saepe ramosis plerumque ex 1-20 conidiis compositis, 3-4.5 x 2.5-4 µm.

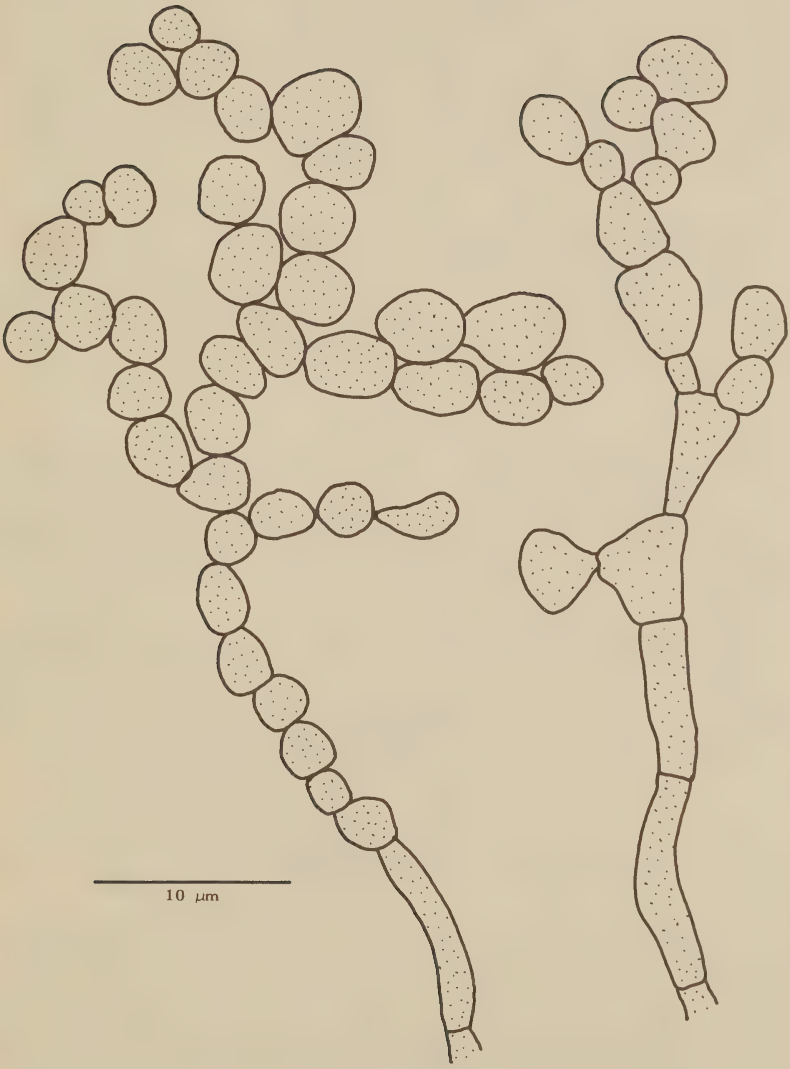

Fig. 3. - *Bispora lichenum* (LG - holotype): Conidiophores and conidia.

Typus: Luxemburgum, E Wahlhausen, Gemünder Akeschterbaach, in hymenio *Opegraphae atrae* ad *Acer*, 18 viii 1986, Diederich 8982 (LG: holotypus; herb. Diederich: isotypus).

Colonies dispersed in the hymenium of the host, scarcely visible macroscopically. Mycelium brownish, septate, smooth-walled, not constricted at the septa, 1 µm diam. Conidiophores semi-macronematous, mononematous, frequently branched, pale brown,smooth-walled, septate, distinctly constricted at the septa, 25-50 µm long and 1.7-3 µm thick. Conidiogenous cells monoblastic, rarely polyblastic, integrated, terminal, subcylindrical to ellipsoid, pale brown. Conidia subspherical to ellipsoid, brownish, simple, rarely 1-septate, thin- and smooth-walled, catenate, with chains often branched, composed of 1-20 conidia, 3-4.5 x 2.5-4 µm.

Hosts: On *Candelariella xanthostigma*, *Opegrapha atra*, *Strangospora pinicola* and on an undescribed lichenicolous *Arthonia* species growing on *Leproloma vouauxii*. The conidiophores develop in the hymenium of the host parallel to the paraphyses, and the conidia are produced in the upper part of the hymenium or on the surface. As the apothecia of the host do not seem do be damaged and as the ascospores are produced normally, the new fungus seems to be a commensal or a weak parasite.

Distribution: Known only from Luxembourg.

Observations: This species recalls *Bispora christiansenii* which has constantly 1-septate conidia and more irregular conidiophores. An "abnormal" specimen of *B. christiansenii* with mostly simple conidia, published and illustrated by Alstrup & Hawksworth (1989), seems to represent also *B. lichenum*. These two fungi do probably not belong to *Bispora* s.s., but the description of a distinct genus seems to be premature as the current concept of *Bispora* is not clearly defined.

Additional specimens: Luxembourg: W Bissen, on *Pyrus*, on *Candelariella xanthostigma*, 14 ix 1979, Diederich 8985 (herb. Diederich). Niederanven, Aarnescht, on *Pyrus*, on *Strangospora pinicola*, 25 viii 1985, Diederich 6660 (herb. Diederich). SSW Bascharage, near the Moulin de Bascharage, on *Malus*, on *Arthonia* sp. (on *Leproloma vouauxii*), 5 viii 1987, Diederich 8324b (herb. Diederich, sub *Arthonia* sp.).

Feltgeniomyces Diederich **gen. nov.**

Genus lichenicola, ad Hyphomycetes pertinens. Conidiophora semi-macronemata, in sporodochiis, mononemata, sparse ramosa, pallide brunnea, levia. Cellulae conidiogenae enteroblasticae, terminales, determinatae, discretae, subcylindricae ad anguste ampulliformae, cum brevi et lato collari, pallide brunneae. Conidia solitaria, semi-endogena vel acrogena, subglobosa ad ellipsoidea, basi truncata, non septata, levia vel subtiliter verruculosa, sicca, brunnea.

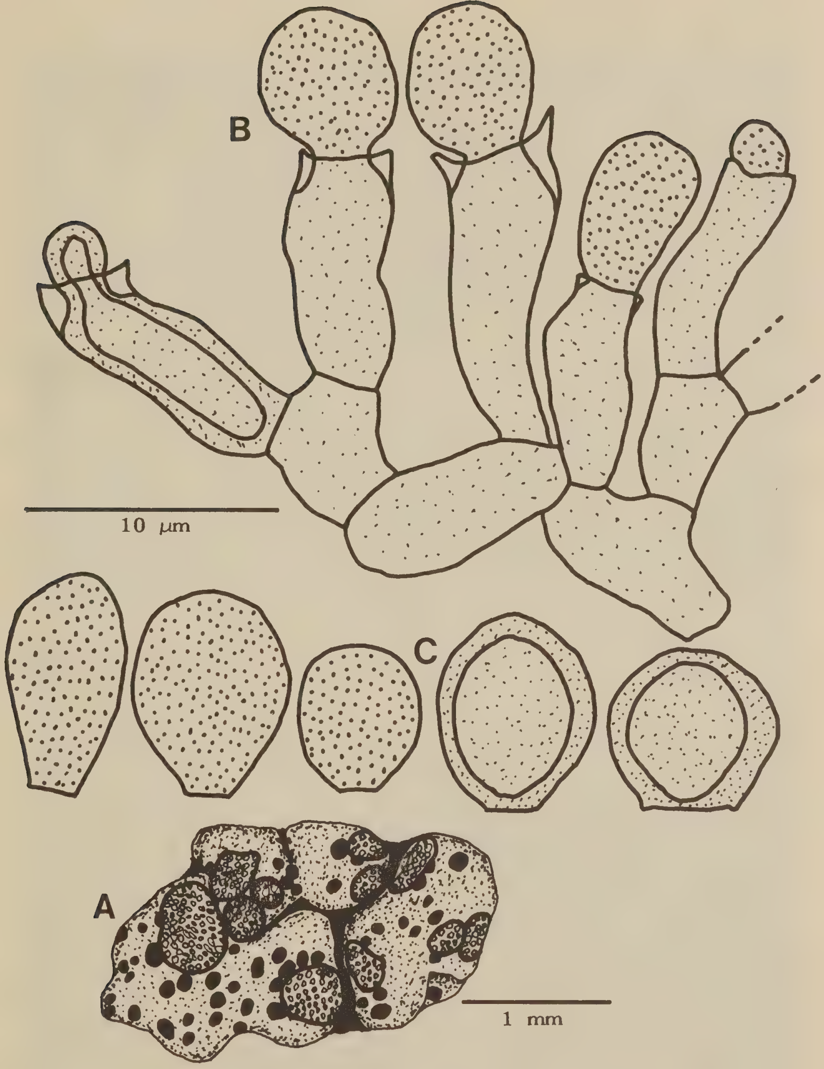

Fig. 4. - *Feltgeniomyces luxemburgensis* (LG - holotype): A, Thallus of *Lecidella conspurcatosorediosa* with 11 soralia and numerous sporodochia. B, Conidiophores, conidiogenous cells and conidia. C, Conidia.

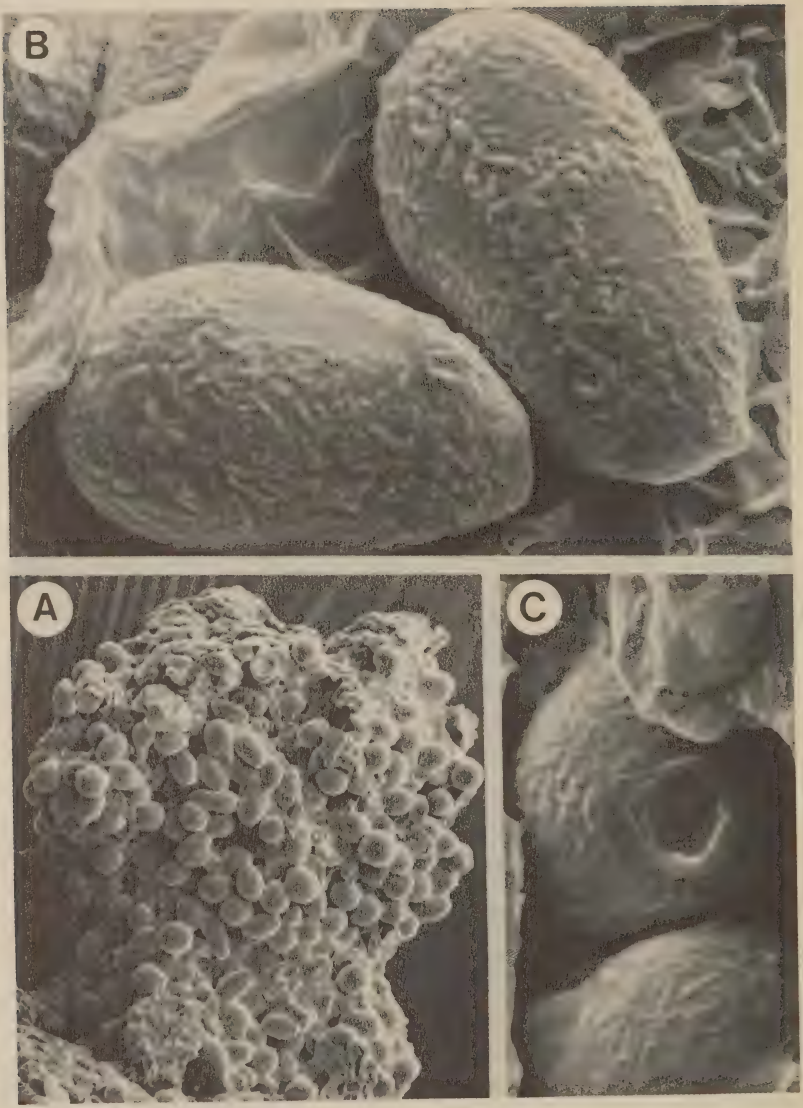

Fig. 5. - *Feltgeniomyces luxemburgensis* (LG - holotype): A, Surface view of sporodochium (x 810). B, Conidia (x 9600). C, Truncated base of conidium (x 9600). Scanning electron micrographs (air dried).

Species holotypica: *F. luxemburgensis* Diederich.

Conidiophores semi-macronematous, forming sporodochia, mononematous, rarely branched, pale brown, smooth-walled. Conidiogenous cells enteroblastic, terminal, determinate, discrete, subcylindrical to narrowly ampulliform, with a short and wide collarette, pale brown. Conidia solitary, semi-endogenous or acrogenous, subspherical to ellipsoid, truncated at the base, simple, smooth-walled or finely verrucose, dry, brown.

Observations: Carmichael & al. (1980) mention only two genera of hyphomycetes with sporodochia, similar conidiogenesis and brown simple conidia: *Stromatocrea* Cooke, the anamorph of *Hypocreopsis* P. Karsten; and *Myrothecium* Tode producing conidia in mucilaginous masses. The conidiogenesis in this new genus recalls that of *Xanthoriicola physciae* (Kalchbr.) D. Hawksw., but in that genus the conidia have a pronounced verrucose ornamentation, and the colonies do not form sporodochia.

Etymology: This genus is named in honour of Dr J. Feltgen (Luxembourg, 1833-1904) in recognition of his important contributions to mycology.

Feltgeniomyces luxemburgensis Diederich **sp. nov.** (Figs. 4-5)

Fungus lichenicola. Mycelium ex hyphis pallide brunneis 1.5-2 µm diam. Conidiophora in sporodochiis atris convexis, 50-125(250) µm diam., cum cellulis 5-8 x 2.5-4.5 µm. Cellulae conidiogenae 6-11 x 3-4.5 µm. Conidia 5-7.5 x 4-6 µm.

Typus: Luxemburgum, NNW Schouweiler, Schullerboesch, in thallo *Lecidellae conspurcatosorediosae* ad *Quercum* in pascuo, 21 viii 1987, Diederich 8477 (LG: holotypus; IMI 335016, UPS, herb. Diederich: isotypi).

Mycelium brownish, smooth-walled, 1.5-2 µm diam. Conidiophores forming black convex sporodochia, 50-125(250) µm diam., with cells 5-8 x 2.5-4.5 µm. Conidiogenous cells 6-11 x 3-4.5 µm. Conidia 5-7.5 x 4-6 µm.

Host: On *Lecidella conspurcatosorediosa* (Harm.) Diederich on *Quercus* in a pasture. As the host thallus does not seem to be damaged, the fungus may be considered as a commensal.

Distribution: Known only from the type locality in Luxembourg.

Etymology: Luxembourg is the native country of Dr Jean Feltgen, but also the country where the new species has been discovered.

Lawalreea Diederich **gen. nov.**

Genus lichenicola, ad Coelomycetes pertinens. Conidiomata pycnidia, immersa, subglobosa vel ellipsoidea, atra, non ostiolata. Conidiophora desunt. Cellulae conidiogenae enteroblasticae, cum brevi collari, discretae, determinatae, ampulliformae vel ellipsoideae, hyalinae, leviae. Conidia non septata, hyalina, levia, falciformia, basi truncata.

Species holotypica: *L. lecanorae* Diederich.

Conidiomata pycnidial, immersed, but sometimes erumpent, subspherical to ellipsoid, dark, without ostiole, opening irregularly at the apex; wall composed of one or several layers of polyhedral to subspherical cells. Conidiophores absent. Conidiogenous cells lining the pycnidial cavity, enteroblastic, with a very short collarette, discrete, determinate, ampulliform to ellipsoid, hyaline, smooth-walled. Conidia simple, hyaline, smooth-walled, falciform, with the greatest width in the upper part, with a rounded apex and a weakly truncated base.

Observations: This genus recalls *Selenophoma* which has similar falciform conidia. In the type species, *S. catananches* Maire, the conidiogenous cells are, however, much shorter and broader and each produce 2-3 conidia which become pale brown and verruculose.

Etymology: This genus is named in honour of Prof. A. Lawalrée (Brussels) in recognition of his invaluable assistance and encouragment to my botanical studies during the last 15 years.

Lawalreea lecanorae Diederich **sp. nov.** (Fig. 6)

Fungus lichenicola. Pycnidia 30-100 µm; paries 5-9 µm crassus, viridis, sed basi hyalinus. Cellulae conidiogenae 5-8 x 2.5-5 µm. Conidia (5)5.5-6.5(7.5) x 2-3 µm.

Typus: Luxemburgum, Roder, Schwarzenhuegel, in *Lecanora persimilis* ad *Betulam*, 23 ix 1966, Lambinon 66/1465b (LG: holotypus; IMI 335015, herb. Diederich: isotypi).

Pycnidia 30-100 µm diam.; wall 5-9 µm thick, with cells 4-7 µm diam., green in the upper part, and hyaline in the lower part, K-. Conidiogenous cells 5-8 x 2.5-5 µm. Conidia (5)5.5-6.5(7.5) x 2-3 µm.

Host: This species is a common parasite on the apothecia, and rarely on the thallus, of *Lecanora persimilis*.

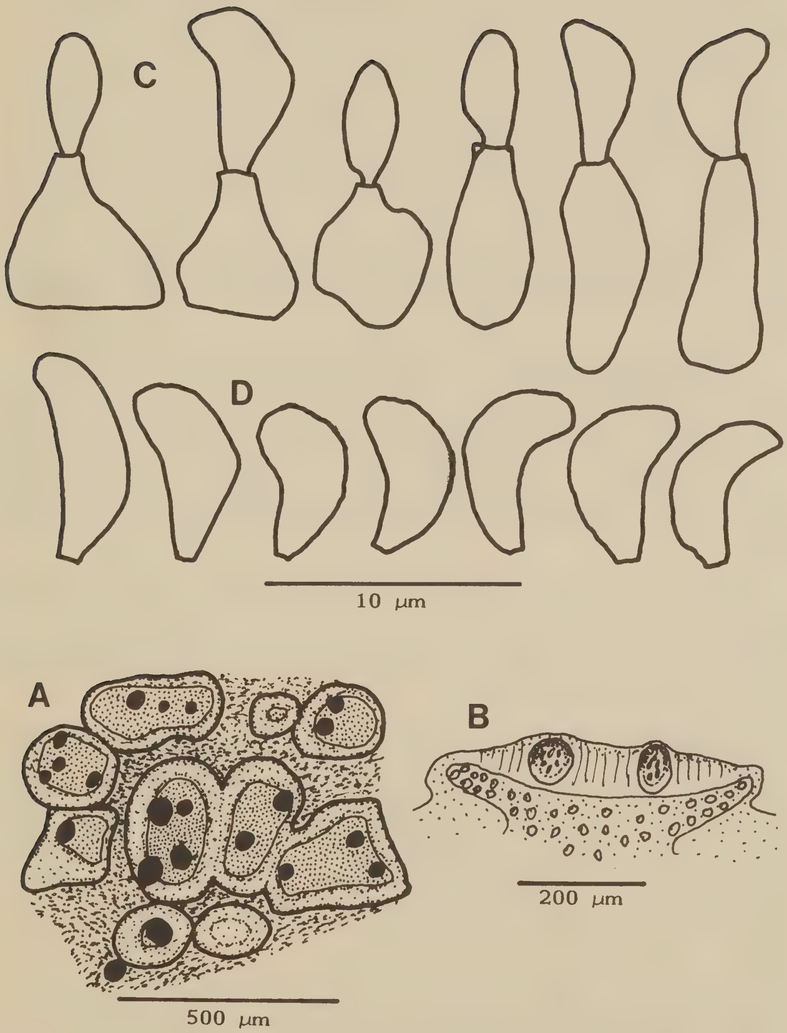

Fig. 6. - *Lawalreea lecanorae* (LG - holotype): A, Thallus and apothecia of *Lecanora persimilis* with pycnidia. B, Vertical section through an apothecium of *L. persimilis* with 2 pycnidia. C, Conidiogenous cells with conidia. D, Conidia.

Distribution: Known only from Luxembourg, where the species is rather common.

Observations: It is interesting to note that several *Lecanora* species, viz. *L. quercicola* Coppins & P. James and *L. saligna* (Schrader) Zahlbr., show the same type of falciform, hyaline, simple, smooth-walled and truncated macroconidia, and similar conidiogenous cells (Coppins & James, 1979: 145-149). Their conidia differ only by the pointed apices and larger dimensions (*L. saligna*: 7-8 x 2-2.6 µm; *L. quercicola*: 8-12 x 3-4 µm). These observations might suggest that the pycnidia belong to *Lecanora persimilis* and not to a distinct fungus. As the pycnidia are frequently found growing in the upper part of the hymenium of *L. persimilis*, and as the apothecia bearing numerous pycnidia are generally dying, I consider that these pycnidia belong to a parasitic lichenicolous coelomycete.

L. lecanorae conceivably also represents the anamorph of a parasitic *Lecanora* species unknown as the teleomorph. To clarify this point it would be interesting to grow in culture *Lawalreea lecanorae* and the two above *Lecanora* species with similar macroconidia.

A third possibility is that the macroconidial pycnidia on *Lecanora saligna* and *L. quercicola* do not belong to those lichens, but represent two further *Lawalreea* species. It is interesting to note that several taxa of lichenicolous coelomycetes have already been described for the pycnidia associated with *L. saligna*: *Phoma curvispora* Vouaux, *P. fusispora* Vouaux, *P. lecanorae* Vouaux p.p., and perhaps *Pseudodiplodia lichenis* Vouaux (see Hawksworth, 1981, Hawksworth & James, 1983). Note also the new genus *Lecanoropsis* M. Choisy described for the *L. saligna* group because of the different pycnidia especially !

Coppins (pers. comm.) has observed that the pycnidial wall in the *L. saligna* group contains the same brown pigment than the apothecia of these lichens. The green pigment found in the pycnidial wall of *Lawalreea lecanorae* is, however, lacking in the apothecia of *Lecanora persimilis*. This confirms my decision that these pycnidia do not belong to *L. persimilis* but to a parasite.

Additional specimens (all on *Lecanora persimilis*): Luxembourg: SW Mersch, Bolaker, 14 ix 1979, Diederich 1842 (herb. Diederich). NW Septfontaines, on *Acer*, 14 ix 1979, Diederich 8977 (herb. Diederich). Schifflange, Brill, on *Populus*, 29 vii 1986, Diederich 8976 (herb. Diederich). SSW Bascharage, near the Moulin de Bascharage, on *Malus*, 5 viii 1987, Diederich 8978 (herb. Diederich). W Schengen, Grouf, on *Populus*, 16 viii 1987, Diederich 8443 (herb. Diederich). NE Bergem, Schéierboesch, on *Populus*, 26 viii 1987, Diederich 8509 (herb. Diederich).

Leptosphaeria ramalinae (Desm.) Sacc., *Syll. fung.* **2**: 84 (1883).

Sphaeria ramalinae Desm., *Ann. Sc. Nat., Bot.*, sér. 3, **11**: 354 (1849).

Phaeospora ramalinae (Desm.) Vouaux, *Bull. Soc. mycol. France* **29**: 74 (1913).

Perithecia subspherical, dark brown, 0.2 mm diam. Wall composed of irregular angular cells of 4-8 µm diam. Hamathecium composed of persistent, partly anastomosing pseudoparaphyses 1.4-2.2 µm. Asci with two functional wall layers, 8-spored. Ascospores fusiform, 3-septate, brown, wall verruculose, 13-16 x 4.5-5.5 µm.

Hosts: *R. fastigiata* (thallus) and *Ramalina* sp.

Distribution: France and Luxembourg.

Observations: The original description of this species is incomplete. The author did not mention paraphyses, and as the presence of 4 guttulae in the ascospores suggests the presence of 3 septa, Vouaux (1913: 74-75) therefore considered that the species belonged to the genus *Phaeospora*. The Luxembourg specimen is very poor, and I could observe and study only one perithecium. For this reason I was unable to study in detail the structure of the asci and of the ostiole. As this specimen agrees sufficiently with the original description, I nevertheless attribute it to *L. ramalinae*.

The appropriate systematic position is uncertain. As pseudoparaphyses are present at maturity, its position in the genus *Phaeospora* is wrong. I leave it provisionally in the genus *Leptosphaeria*, as suggested by Saccardo, but the presence of verrucose ascospores distinguishes it from the type species of that genus, *L. doliolum* (Pers.) Ces. & de Not. More material is necessary for a final decision.

Specimen examined: Luxembourg: Hoscheid, on *Ramalina fastigiata* on *Fraxinus*, 9 ix 1967, Van Wersch s.n. (herb. Diederich 6354).

Marchandiomyces Diederich & D. Hawksw. **gen. nov.**

Genus lichenicola, ad Hyphomycetes pertinens. Coloniae sclerotia vel sporodochia subglobosa cellulis hyalinis polyedricis vel subglobosis compositae. Conidiophora semi-macronemata, recta, ad basim ramosa, hyalina, levia. Cellulae conidiogenae monoblasticae, determinatae, integratae, terminales, ellipsoideae vel subcylindricae, hyalinae, non septatae, leviae. Conidia solitaria, non septata, obpyriformia vel obovoidea, basi truncata, hyalina, subtiliter verrucosa.

Species holotypica: *M. corallinus* (Roberge) Diederich & D. Hawksw.

Colonies delimited, forming subspherical sclerotia, sometimes developing into convex sporodochia, composed internally of polyhedral or subspherical hyaline cells. Conidiophores semi-macronematous, erect, branched at the base, hyaline, thick- and smooth-walled. Conidiogenous cells monoblastic, determinate, integrated, terminal, ellipsoid to subcylindrical, hyaline, simple, thick- and smooth-walled. Conidia solitary, simple, obpyriform to obovoid, distinctly truncated at the base, hyaline, wall thick and finely verrucose.

Observations: I describe this new genus together with Prof. D. L. Hawksworth who recognized earlier (Hawksworth, 1979) that its type species could hardly be retained in the genus *Illosporium*. No other genus of hyphomycetes seems to be suitable for this species.

Etymology: This genus is named in honour of Louis Marchand (1807-1843), the first Luxembourg mycologist and lichenologist, and the only Luxembourg botanist to publish on lichenicolous hyphomycetes before 1986 (concerning *Aecidium peltigerae* DC. = *Illosporium carneum* Fr. and *Tubercularia rosea* Pers. = *Marchandiomyces corallinus*) (Marchand, 1826: 409, 1829: 270-271).

Marchandiomyces corallinus (Roberge) Diederich & D. Hawksw. **comb. nov.**

(Fig. 7)

Basionym: *Illosporium corallinum* Roberge, in Desmazières, *Pl. crypt. Fr.*, Ed. 1, fasc. 32, no. 1551 (1847).

Aegerita physciae Vouaux, *Bull. trimest. Soc. mycol. Fr.* **30**: 314 (1914).

(See Hawksworth, 1979 for further synonyms.)

Colonies superficial or slightly immersed in the lichen thallus, sclerotia 50-150 µm diam., sporodochia 100-500 µm diam., with cells 6-10 µm diam. Conidiophores developing at the surface of the sporodochia, simple or septate, ellipsoid, claviform or subcylindrical, 15-35 x 3-9 µm. Conidiogenous cells 9-11 x 4-9 µm. Conidia 11-15 x 7-10 µm.

Hosts: In addition to the numerous hosts mentioned by Hawksworth (1979: 236), I have collected this species on *Parmelia exasperatula*, *Phaeophyscia orbicularis*, *Physcia caesia* and *Xanthoria candelaria*.

Distribution: This is a very common lichen parasite in many parts of Europe, and also occurs in North America.

Observations: The conidiogenesis of this species has not been described previously. Hawksworth (1979) only studied sclerotia composed of subspherical cells that he provisionally considered as conidiophores, conidiogenous cells and conidia developing in sporodochia. Later Lowen & al. (1986) recognized that the colonies actually represent sterile sclerotia unable to produce conidia, and they suggested that *M. corallinus* might represent a synanamorph of *Hobsonia christiansenii* Brady & D. Hawksw. able to produce conidia in conditions of high atmospheric humidity. The discovery that both species contain the same pigments encouraged this hypothesis. Furthermore, Hawksworth (1979) noted that *M. corallinus* varies in colour from orange

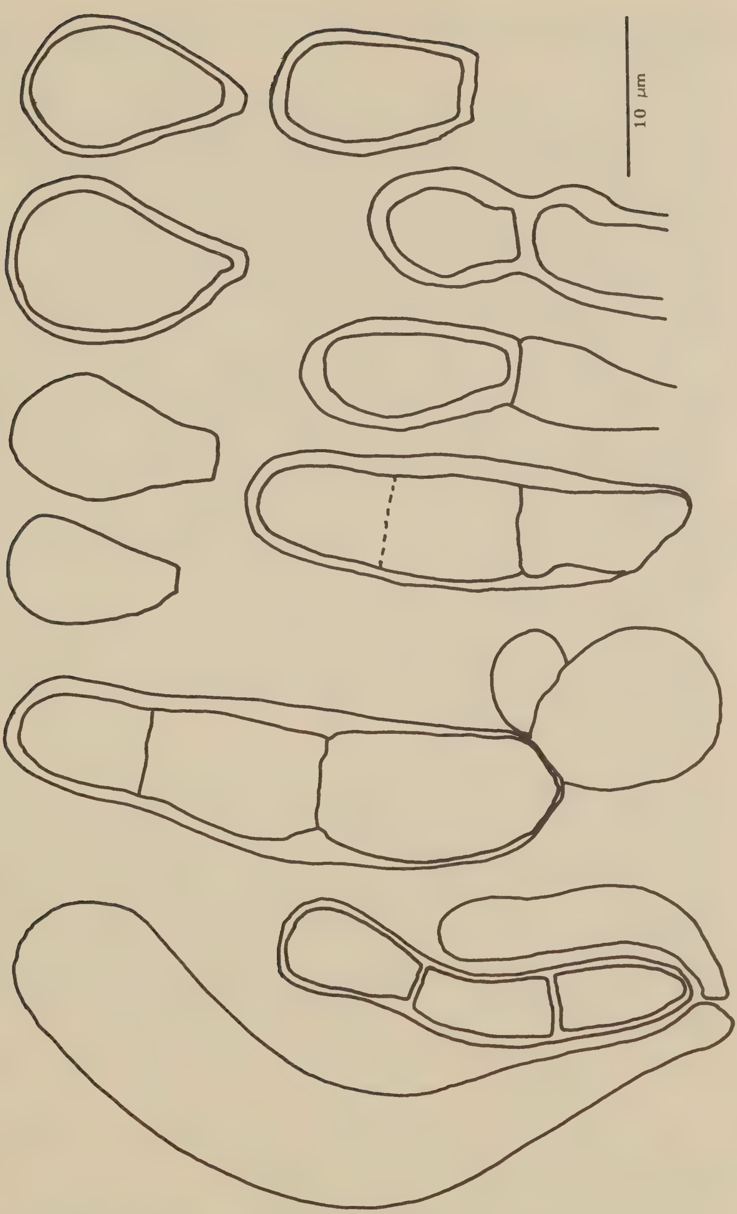

Fig. 7. - *Marchandiomyces corallinus* (Diederich 8526): Conidiophores, conidiogenous cells and conidia.

to pink and red, and that it has sometimes the same colour as the sporodochia of *H. christiansenii*.

I had the chance to study both *M. corallinus* and *H. christiansenii* many times in the field under wet conditions, and I could even find several lichen thalli attacked by both parasites. My observations showed that fresh and moist colonies of *M. corallinus* are always orange, whilst those of *H. christiansenii* are always pinkish or crimson. These colours hardly vary in fresh material, and no intermediates have been found.

The different colours of *M. corallinus* noted by Hawksworth (1979) appear to be primarily due to changes in colour of old herbarium specimens, but there may be further undescribed species. One Luxembourg specimen (Diederich 8442, herb. Diederich) with brown sporodochia seems to have a similar conidiogenesis as *M. corallinus*, and might represent such an undescribed species.

M. corallinus and *H. christiansenii* are two morphologically very distinct species, and field observations did not reveal any intermediates or transitions; microscopically *H. christiansenii* is easily distinguished by its helicoidal conidia. The presence of the same pigments in two species that otherwise have the same ecology, and parasitize the same hosts does, however, lead me to retain the possibility that they might represent two conidial states of one species as suggested by Lowen & al. (1986). This question can be resolved only by culturing the two species together, and I suggest urgently that the discovery of fresh material of *M. corallinus* producing conidia should be used to try a culture.

Although the type specimen of *Aegerita physciae* Vouaux has been lost (Hawksworth, 1979: 268), this name appears to be a later synonym of *M. corallinus*. The original description of *A. physciae* agrees well with the current concept of *M. corallinus*, with the exception that Vouaux described spherical conidia without mentioning their truncated base.

Additional specimens: Luxembourg: SSW Bascharage, near the Moulin de Bascharage, on *Salix*, on *Physcia tenella*, 5 viii 1987, Diederich 8353 (herb. Diederich). NE Bergem, Schéierboesch, on *Populus*, on *Phaeophyscia orbicularis*, *Physcia adscendens*, *P. tenella*, *Xanthoria candelaria* and *X. parietina*, 26 viii 8.1987, Diederich 8513, 8515, 8516, 8517, 8518, 8519 (herb. Diederich, LG). Dudelange, vers Zoufftgen, on *Populus*, on *P. tenella*, 27 viii 1987, Diederich 8526 (herb. Diederich). SE Lasauvage, Grand-Bois, on *Acer*, on *P. tenella*, 29 viii 1987, Diederich 8568 (herb. Diederich). Hellange, Bëltzacker Weiher, on *Salix*, 27 xii 1987, Marson s.n. (herb. Diederich 8883a). Kapweiler, on *Salix*, on *P. tenella*, 28 ii 1988, Diederich 8895 & Marson (herb. Diederich).

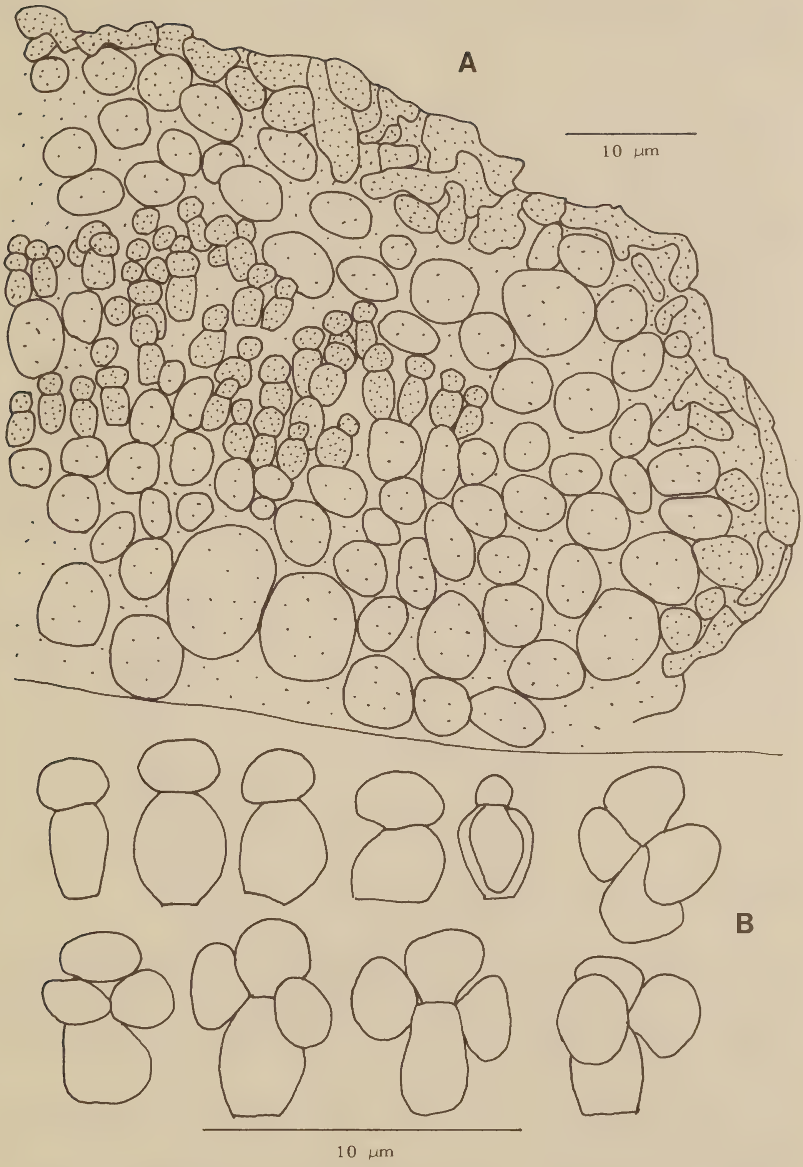

Fig. 8. - *Phaeosporobolus usneae* (Diederich 8971): A, Vertical section through a stroma showing the conidiogenesis. B, Conidiogenous cells with 1-3 subspherical young conidia.

Phaeosporobolus usneae D. Hawksw. & Hafellner, *Nova Hedw.* **43**: 525 (1986) (Fig. 8)

For a detailed description, see Hawksworth & Hafellner (1986), and my observations below.

Hosts: In addition to the hosts mentioned by Hawksworth & Hafellner (1986: 526) I have collected *P. usneae* on *Buellia griseovirens*, *Fuscidea viridis*, *Lecanora pulicaris*, *Ochrolechia androgyna*, *Pertusaria albescens* var. *albescens*, *P. a.* var. *corallina*, *P. amara* and *P. pertusa*. It is interesting to note that *P. usneae* is very frequent on the lichens listed above, but is absent on most other epiphytic microlichens in Luxembourg. For instance, it is present on most specimens of *Lecanora pulicaris*, but does not grow on adjacent thalli of *Lecanora conizaeoides* or *L. expallens*.

Distribution: Europe and North America.

Observations: A careful study of many conidiomata of different ages resulted in a better understanding of the conidiogenesis. The conidia originate from subspherical subhyaline cells situated inside the stroma. The conidiogenous cells are not constantly monoblastic, but generally polyblastic. The multicellular conidia of 5-20 µm diam. are an assemblage of one conidiogenous cell and its products.

By finding specimens whose conidiogenous cells initially produce 1-3 simple and extremely small conidia, I originally thought that this was a distinct species. I was however rapidly convinced that the dimensions of the conidia vary strongly during their development, and that the conidia described and illustrated by Hawksworth & Hafellner (1986) represent an advanced stage.

Additional specimens: See Diederich & al. (1990).

Polycoccum tinantii Diederich **sp. nov.** (Fig. 9)

Fungus lichenicola. Ascomata dispersa, superficialia vel parte immersa, subglobosa, atra, 0.17-0.28 mm diam.; paries atrobrunneus, 24-33 µm crassus, cellulis polyedricis, 4-8 µm diam. Pseudoparaphyses ramosae et anastomosantes, 1-1.5 µm crassae. Asci elongati vel clavati, bitunicati, 8-spori, in iodo non caerulescentes. Ascosporae ellipsoideae, 1-septatae, brunneae, subtiliter verruculosae, 18-26 x 7.5-11 µm.

Typus: Luxemburgum, s. loc., in thallo *Caloplacae ferrugineae*, ante 1850, Tinant 484a (LUX: holotypus).

Ascomata dispersed on the host thallus, superficial or little immersed, subspherical, black, 0.17-0.28 mm diam.; wall dark brown, 24-33 µm thick, composed of polyhedral

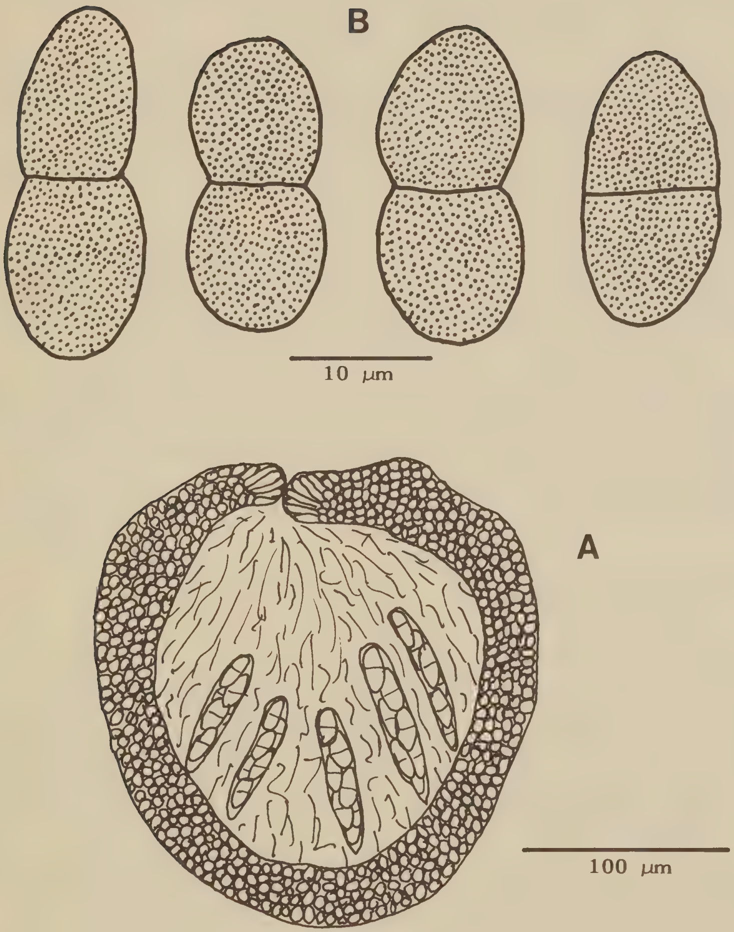
B
10 μm
A
100 μm

Fig. 9. - *Polycoccum tinantii* (LUX - holotype): A, Vertical section through an ascoma. B, Ascospores.

cells of 4-8 µm diam., cells elongated near the ostiole. Pseudoparaphyses branched and anastomosing, septate, 1-1.5 µm thick, becoming faintly blue in iodine. Asci elongated to claviform, with two functional wall layers, thick-walled, 8-spored, not reacting in iodine. Ascospores ellipsoid, 1-septate, with cells equal in size, wall constricted near the septum, brown, finely verrucose, 18-26 x 7.5-11 µm.

Host: This species, known only from the type specimen, grows as a commensal on the thallus of *Caloplaca ferruginea*. It represents only the second species of the genus growing on corticolous lichens, the other being *P. innatum* (Müll. Arg.) D. Hawksw.

Distribution: Known only from the type specimen from Luxembourg (no precise locality).

Observations: This species recalls *P. sporastatiae* (Anzi) Arnold whose ascospores are slightly shorter, but distinctly narrower: 16-23(25) x 6-9.5(12) µm. In addition the ascomata of *P. sporastatiae* are immersed in convex deformations on lichens belonging to the genus *Sporastatia*.

Etymology: Named after the Luxembourg botanist F. A. Tinant (1803-1853) who collected this species, and whose lichen herbarium with more than 1000 specimens is the only serious available source of information on Luxembourg lichens from the beginning of the 19th century.

Pyrenochaeta xanthoriae Diederich **sp. nov.** (Fig. 10)

Fungus lichenicola. Pycnidia primo immersa, erumpescentia, ellipsoidea, 80-125 µm alta et 50-90 µm diam., cum setis prope ostiolum; setae atrobrunneae, leviae, 30-70 x 3.5-5 µm, 3-5-septatae; paries cellulis polyedricis vel subglobosis, 4-7 µm crassus. Conidiophora elongata, filiformia, septata, hyalina, 4-18 x 1-1.8 µm. Cellulae conidiogenae enteroblasticae, integratae, crescentiae sub conidiophorum septis atque rami laterales brevissimi, hyalinae, leviae. Conidia hyalina, non septata, ellipsoidea, 3-3.5(4) x 1.4-1.8(2) µm.

Typus: Luxemburgum, SE Lasauvage, Grand-Bois, in *Xanthoria parietina* ad *Acer*, 29 viii 1987, Diederich 8970 (LG: holotypus; herb. Diederich: isotypus).

Pycnidia first immersed in the host, becoming superficial, ellipsoid, 80-125 µm high and 50-90 µm diam., with setae near the ostiole; setae dark brown, thick- and smooth-walled, 30-70 µm long and 3.5-5 µm wide, 3-5-septate, the terminal cell being paler and finely verrucose; pycnidial wall composed of several layers of polyhedral to subspherical cells, 4-7 µm thick. Conidiophores elongated, filiform, with several septa, hyaline, lining the pycnidial cavity, 4-18 x 1-1.8 µm. Conidiogenous cells enteroblastic, integrated, appearing as very short lateral branches just below each septum of the

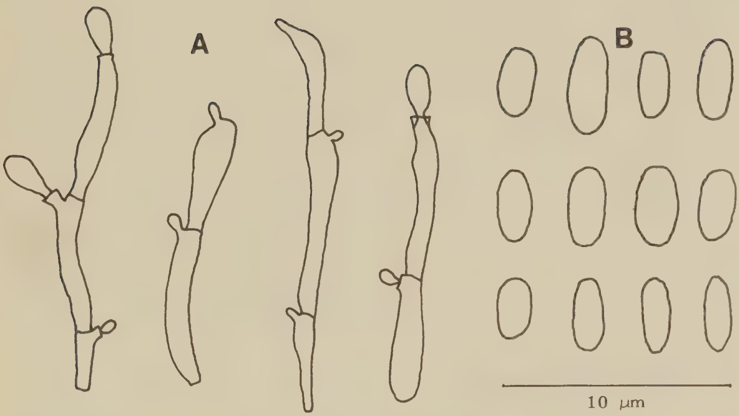

Fig. 10. - *Pyrenochaeta xanthoriae* (LG - holotype): A, Conidiophores and conidiogenous cells. B, Conidia.

conidiophores, hyaline, smooth-walled. Conidia hyaline, simple, smooth-walled, ellipsoid, 3-3.5(4) x 1.4-1.8(2) μm.

Host: Parasitic on the apothecia and thallus of *Xanthoria parietina*. In the type specimen it is accompanied by *Marchandiomyces corallinus*, *Lichenoconium xanthoriae*, and other saprophytic or parasitic hyphomycetes.

Distribution: Known only from Luxembourg.

Observations: *P. xanthoriae* is easily distinguished from the other species of the genus by the very reduced pycnidia and conidia, and by its lichenicolous habitat. It represents the first lichenicolous member of the genus, since *P. collematis* Vouaux with different conidiogenous cells should be transfered to another genus (Hawksworth, 1981: 84).

Additional specimen: Luxembourg: NE Bergem, Schéierboesch, on *Populus*, on *Xanthoria parietina*, 26 viii 1987, Diederich 8973 (herb. Diederich).

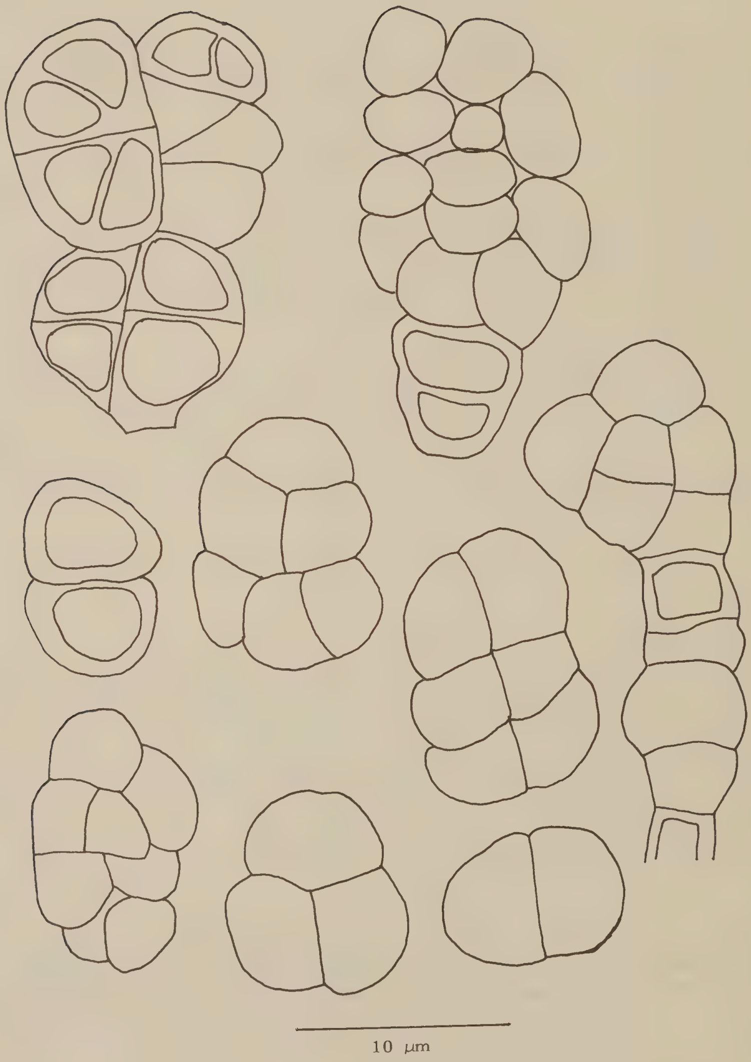

Fig. 11. - *Sclerococcum epiphytorum* (IMI 335013 - holotype): Conidiophores, conidiogenous cells and conidia.

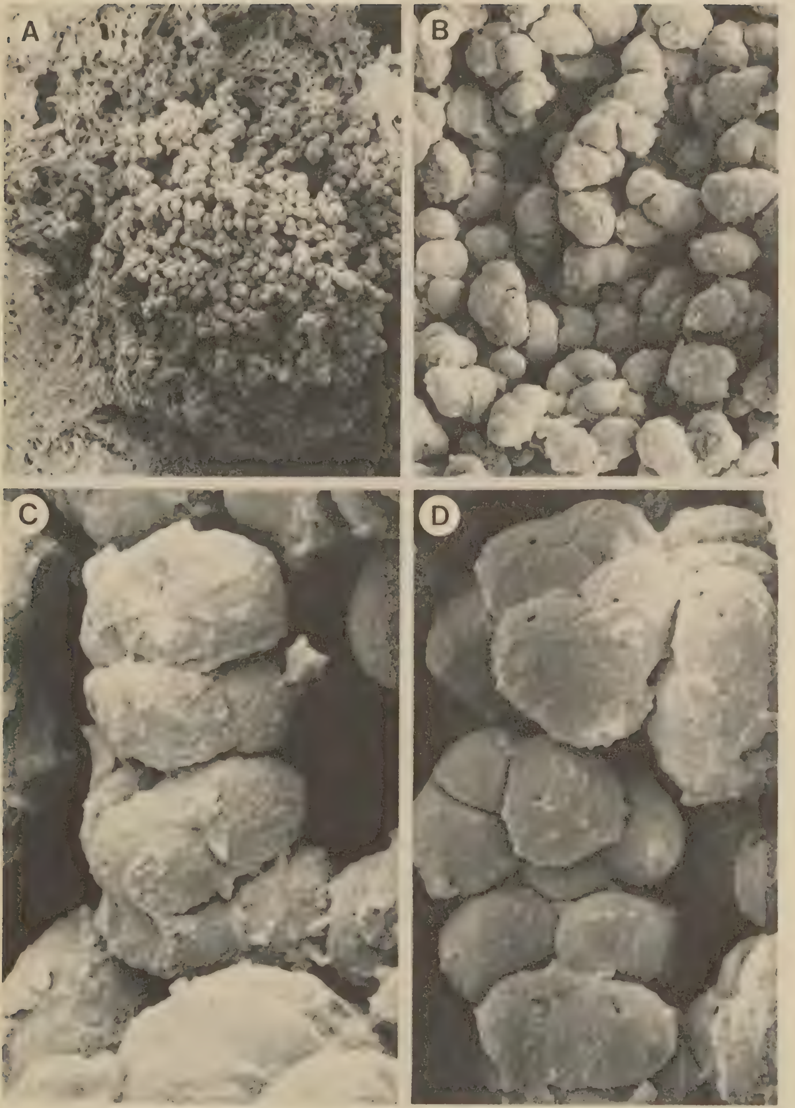

Fig. 12. - *Sclerococcum epiphytorum* (IMI 335013 - holotype): A, Surface view of sporodochium (x 210). B, Group of conidia (x 1100). C, Conidium (x 4350). D, Conidia showing scars left by secession of other conidia (x 3800). Scanning electron micrographs (air dried).

Sclerococcum epiphytorum Diederich **sp. nov.** (Figs. 11-12)

Fungus lichenicola. Conidiophora in sporodochiis densis convexis atrobrunneis, rotundatis vel elongatis, (175)225-500(750) µm diam., semi-macronemata, simplicia, atrobrunnea. Cellulae conidiogenae monoblasticae, integratae, terminales, determinatae, ellipsoideae, atrobrunneae. Conidia variabilia, in catenis irregularibus compactis, atrobrunnea, 9-15 x 6-10 µm, 2-7 cellulis subglobosis 3-6 µm diam., levia vel subtiliter verruculosa.

Typus: Luxemburgum, E Lieler, Buch, in thallo *Pertusariae hemisphaericae* ad *Quercum*, 18 viii 1986, Diederich 7248 (IMI 335013: holotypus; LG, herb. Diederich: isotypi).

	S. epiphytorum	**S. sphaerale**
Dimension of sporodochia	(175)225-500(750) µm	(125)170-350(500) µm
Colour of sporodochia	dark reddish brown	dark brown to black
Surface of sporodochia (x 40)	conidia granular, easily visible, matt, not arranged in groups	conidia hardly visible, slightly shiny, often arranged in groups of 30-70 µm
Colour of conidia	reddish brown, rarely dark brown	reddish brown to dark brown
Dimensions of conidia	9-15 x 6-10 µm	10-15 µm diam.
Number of cells per conidium	2-7	2-6
Diameter of conidial cells	3-6 µm	(4)6-10 µm
Hosts	*Pertusaria hemisphaerica*	*P. ceuthocarpoides*, *P. corallina*, *P. dealbescens*, *P. pseudocorallina*
Habitat	corticolous	saxicolous

Table 1. Diagnostic features for the separation of *Sclerococcum epiphytorum* and *S. sphaerale*.

Colonies forming convex dark reddish brown, rounded or rarely elongated, sporodochia (175)225-500(750) µm (n = 50) diam.; mycelium immersed in the host thallus. Conidiophores semi-macronematous, not branched, agglomerated in very dense sporodochia, reddish brown. Conidiogenous cells monoblastic, integrated, terminal, determinate, ellipsoid, reddish brown. Conidia variable in form, produced as irregular compact chains, reddish brown, 9-15 x 6-10 µm, composed of 2-7 subspherical cells of 3-6 µm diam., with a smooth or finely verrucose surface.

Host: This species, only known from the type specimen, grows as a commensal on the thallus of *Pertusaria hemisphaerica* on *Quercus*.

Distribution: Known only from the type locality in Luxembourg.

Observations: For a long time I hesitated to separate this species from *S. sphaerale* (Ach.) Fr. on account of a few minor differences. As the macroscopic aspect differs slightly, but distinctly, and because of the different ecology - *S. sphaerale* is known only from saxicolous *Pertusaria* species (especially *P. corallina* (L.) Arnold) - I regard it as a new species. Table 1 gives the diagnostic features for the separation of the two species. The new species is separated from *S. sphaerale* by its dark reddish brown and not black sporodochia, the paler conidia composed of smaller cells, and the different habitat.

Taeniolella chrysothricis Diederich **sp. nov.** (Figs. 13-14)

Fungus lichenicola. Mycelium partim immersum, ex hyphis pallide brunneis et levibus, 2-3 µm diam. Conidiophora semi-macronemata, mononemata, partim erecta, basi ramosa, septata, brunnea, levia, 30-70 x 3.5-5 µm. Cellulae conidiogenae monoblasticae, integratae. Conidia catenata, ovalia vel subcylindrica, interdum infirme truncata, 1-septata, septis non constricta, pallide brunnea, 8-11.5 x 2.5-3.5 µm, levia vel rugosa, cum pariete exteriore findente.

Typus: Luxemburgum, E Carelshaff (Ettelbruck), in thallo *Chrysothricis candelaris* ad *Quercum*, 10 ix 1986, Diederich 7490 (IMI 335014: holotypus; LG, herb. Diederich: isotypi).

Colonies dispersed, effuse, pale brown; mycelium partly immersed, brownish, thin- and smooth-walled, 2-3 µm diam. Conidiophores semi-macronematous, mononematous, partly erect, branched at the base, septate, brown, smooth-walled, 30-70 µm long and 3.5-5 µm thick. Conidiogenous cells monoblastic, integrated. Conidia catenate, oval to subcylindrical, sometimes weakly truncated, 1-septate, not constricted at the septa, pale brown, 8-11.5 x 2.5-3.5 µm, smooth-walled or rugose, the outer wall splitting and breaking up into patches or stripes of 1-3 µm.

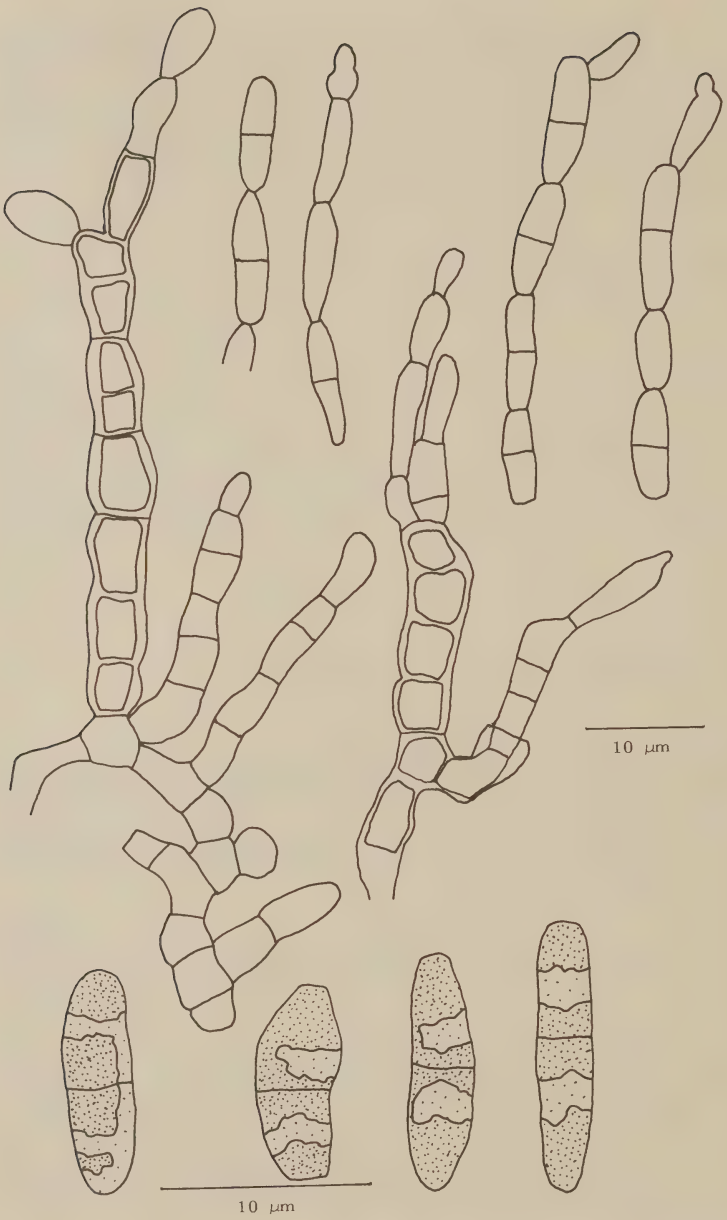

Fig. 13. - *Taeniolella chrysothricis* (IMI 335014 - holotype): Conidiophores, conidiogenous cells and conidia.

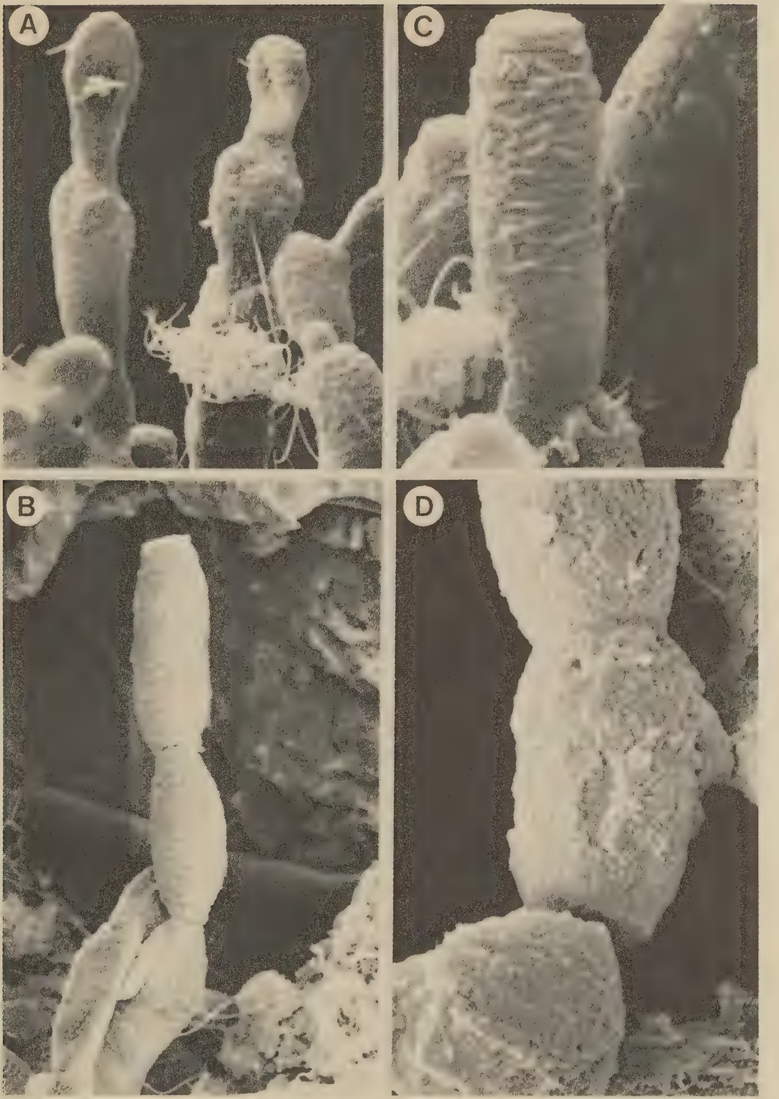

Fig. 14. - *Taeniolella chrysothricis* (IMI 335014 - holotype): A, Conidiophores (x 4000). B, Catenate conidia (x 3500). C, Rugose surface of young conidium (x 7000). D, Splitting outer wall of older conidia (x 7000). Scanning electron micrographs (air dried).

Host: This species grows on the thallus of *Chrysothrix candelaris*. The invaded parts of the thallus become brownish, and the soredia seem to disintegrate, indicating that the fungus is a parasite.

Distribution: Known only from Luxembourg.

Observations: This is the second lichenicolous *Taeniolella* species in which the outer wall of the conidia disintegrates. The remaining parts of the wall are much larger than in the other species, *T. verrucosa* M. S. Christ. & D. Hawksw. A third species with conidia presenting this feature will be described below. *T. chrysothricis* is the first species in the genus whose conidia are paler and narrower than the conidiophores. Finally the conidia of this species are narrower than in the other known *Taeniolella* species.

Additional specimen: Luxembourg: SEE Beaufort, Halerbaach, on *Chrysothrix candelaris* on *Fagus*, 23 ix 1986, Diederich 7638 (herb. Diederich).

Taeniolella trapeliopseos Diederich **sp. nov.** (Figs. 15-16)

Fungus lichenicola. Mycelium immersum, ex hyphis brunneis et levibus, 2-4 µm diam. Conidiophora semi-macronemata, mononemata, erecta, basi ramosa, septata, atrobrunnea, verrucosa, 40-90 x 5-7 µm. Cellulae conidiogenae monoblasticae, integratae. Conidia solitaria, ellipsoidea, (0)1-2-septata, septis raro constricta, atrobrunnea, truncata, verrucosa, cum verrucis 0.5-1.5 µm diam., 13-18 x 6.5-7 µm.

Typus: Luxemburgum, SW Gonderange, Kripsweieren, in thallo *Trapeliopseos flexuosae* ad *Pinum*, 1 v 1986, Diederich 8959 (LG: holotypus; herb. Diederich: isotypus).

Colonies dispersed, effuse, dark brown; mycelium brown, thin- and smooth-walled, 2-4 µm diam. Conidiophores semi-macronematous, mononematous, erect, branched in the lower part, septate, dark reddish brown, with a thick and verruculose wall, 40-90 µm long and 5-7 µm thick, with 1-4 percurrent proliferations. Conidiogenous cells monoblastic, integrated, thickness variable due to the proliferations. Conidia solitary, ellipsoid, (0)1-2-septate, rarely constricted at the septa, dark brown, truncated at the base, thick-walled, the outer wall splitting and breaking up into small verrucae of 0.5-1.5 µm diam., 13-18 x 6.5-7 µm.

Host: Parasitic on *Trapeliopsis flexuosa*. The infected thallus becomes brownish and is rapidely killed.

Distribution: Known only from Luxembourg.

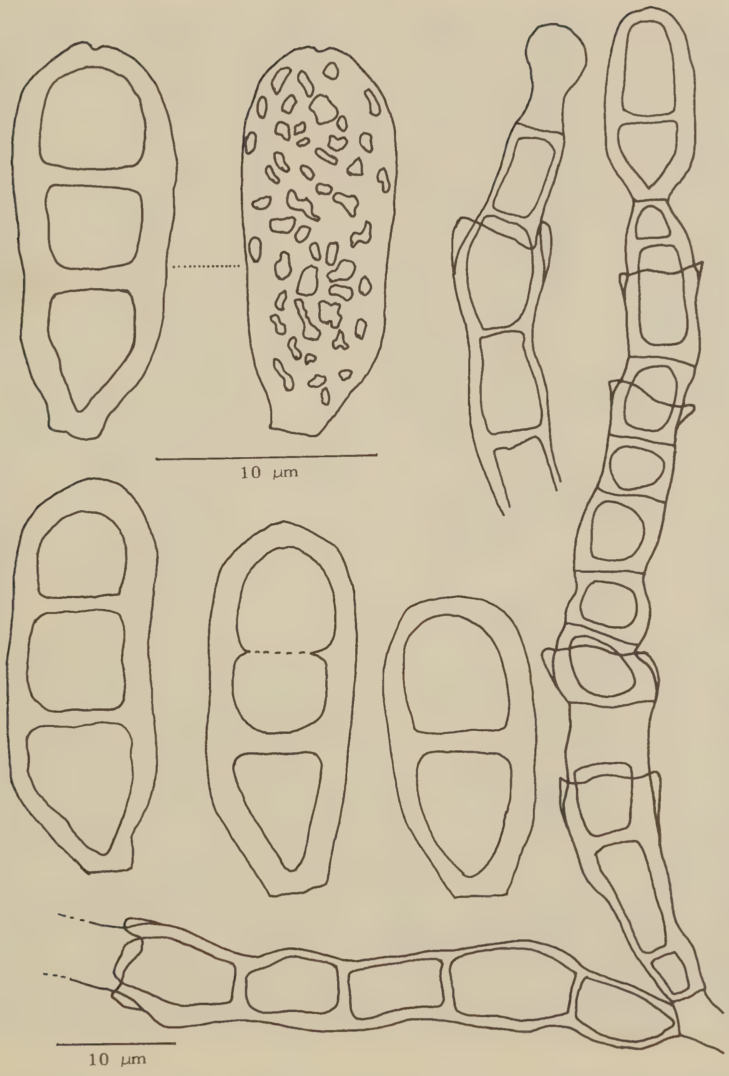

Fig. 15. - *Taeniolella trapeliopseos* (LG - holotype): Conidiophores, conidiogenous cells and conidia.

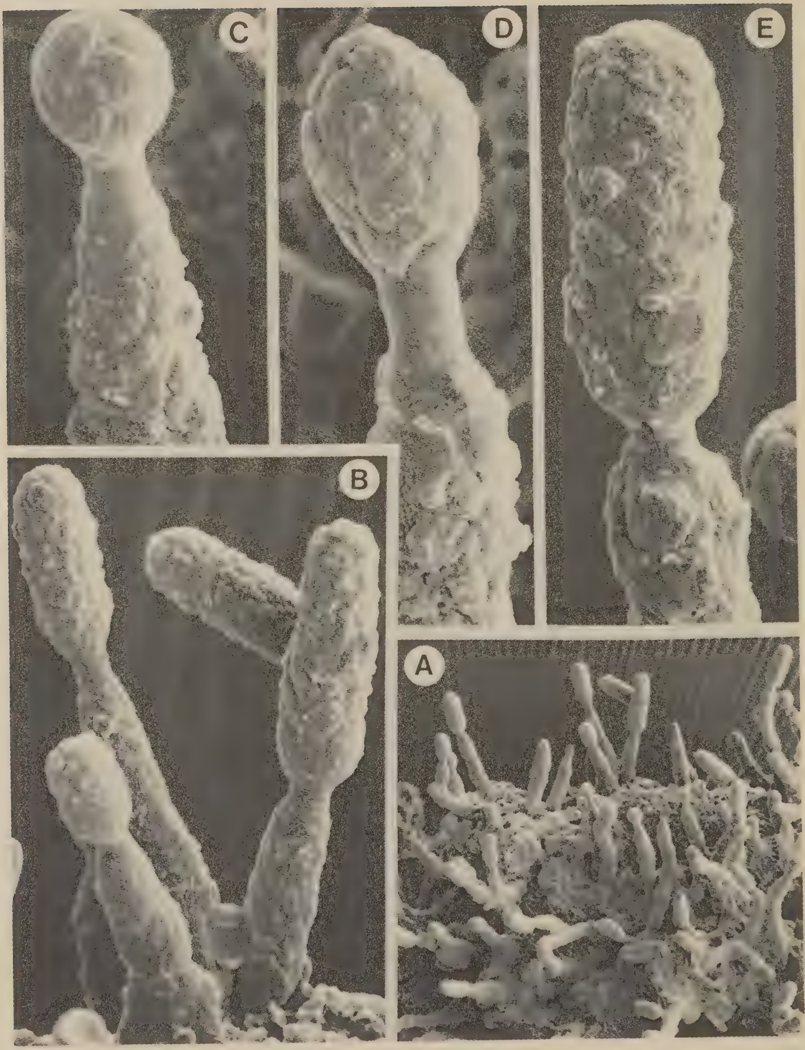

Fig. 16. - *Taeniolella trapeliopseos* (LG - holotype): A, Colony (x 420). B, conidiophores (x 1900). C, Non-septate conidium (x 3800). D, 1-septate conidium (x 4800). E, 2-septate conidium (x 4000). Scanning electron micrographs (air dried).

Observations: This species recalls *Taeniolella verrucosa*, but the verrucae resulting from the disintegration of the outer conidial wall are smaller, the conidia are longer and narrower and are 2-septate at maturity. As the conidia are generally solitary and not catenate, the new species most probably requires a new genus; such a decision should, however, await a global revision of the species attributed to *Taeniolella*.

Additional specimen: Luxembourg: E Fouhren, Hinkelsbaach, on *Trapeliopsis flexuosa* on wood, 18 viii 1986, Diederich 8960 (herb. Diederich).

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A NEW SPECIES OF *POLYPORUS* (APHYLLOPHORALES: POLYPORACEAE) FROM MEXICO

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SUMMARY

Polyporus tenuiparies is described as a new species from the Sierra Occidental of the State of Chihuahua, Mexico. It differs from other species of *Polyporus* in its sinuous skeletal hyphae with relatively thin walls (0.5-0.7 µm thick). It was collected from a dead branch of *Quercus chihuahuensis* in which it caused a white rot.

RESUMEN

Polyporus tenuiparies se describe como nueva especie de la Sierra Madre Occidental del Estado de Chihuahua, México. Se diferencia de otras especias de *Polyporus* por sus hifas esqueléticas sinuas y con paredes relativamente delgadas (0.5-0.7 µm). Se colectó sobre una rama muerta de *Quercus chihuahuensis*, en cual causa putrefacción blanca.

The genus *Polyporus* Fr. as presently conceived includes 18 species in North America (Gilbertson and Ryvarden 1986). Several other species of *Polyporus sensu stricto* have been reported from Mexico (Guzman and Herrera 1971). All known species possess conspicuous skeletal hyphae with dendritic branching and extremely thick walls (up to 2.5 µm). One of us (JEL) recently collected specimens of a *Polyporus* from the Sierra Occidental of the State of Chihuahua, Mexico. These specimens have a very distinctive hyphal system with sinuous skeletal hyphae with walls only slightly thicker than those of the generative hyphae. It is hereby described as a new species.

POLYPORUS TENUIPARIES Lafer. & Gilbn., *sp. nov.*

Pileus circularis ad flabelliformis vel reniformis, usque ad 4 cm latum, 2.5 cm longum, et 3 mm crassum, azonus, concavus, lateraliter substipitatus, aspectu squamuloso; pori anguste rhombici, usque ad 1.5 mm lati et 3 mm longi; systema hypharum dimiticum; hyphae generatoriae fibulatae, hyalinae, interdum ramosae, 3-7 mm diam, tenuitunicatae; hyphae skeletales hyalinae, sinuatae vel contortae, constrictionibus et tumoribus frequentibus, interdum ramosae, nonseptatae, 2.5-7 µm

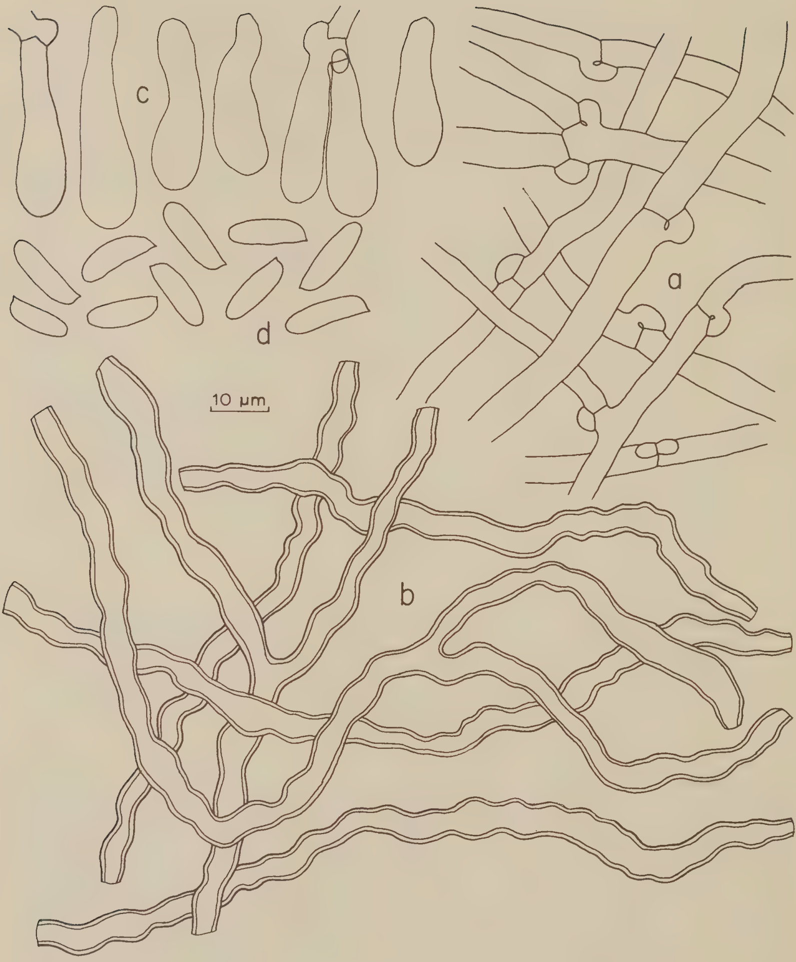

Figure 1. *Polyporus tenuiparies* (Laferrière 602, type). a, contextual generative hyphae; b, contextual skeletal hyphae; c, basidia; d, basidiospores.

diam, parietibus leviter crassis vel firmis, 0.5-0.7 µm crassis; basidiosporae cylindricae, hyalinae, leves, parietibus angustus, nonamyloidae, 10-14 x 4.0-4.5 µm. Holotypus: J.E. Laferrière No. 602, *ad ramum emortuum Quercus chihuahuensis* Trel., Nabogame, Municipio Témosachi, Chihuahua, Mexico, 30 July 1987 (BPI, Isotypus ARIZ, XAL). Etymology: thin-walled, in reference to the skeletal hyphae.

Basidiocarps annual, laterally stipitate, single; pileus circular to flabelliform or reniform, up to 4 cm wide, 2.5 cm long, and 3 mm thick, bright orange-brown when fresh, drying pale brown, with radially appressed tufts of fibrils giving a squamulose appearance, azonate, concave; margin revolute; pore surface whitish to pale orange, drying ivory; context white, soft and cottony, 0.5-2.0 mm thick; tube layer ivory, drying brittle and firm, up to 2 mm thick, decurrent on stipe; pores narrowly rhombic, radially elongate, up to 1.5 mm wide and 3 mm long; dissepiments thin, entire, minutely fimbriate; stipe reduced to narrowed basal portion, white and tomentose at the base or with tubes decurrent to the substrate, 4-5 mm thick and 2-3 mm long on the sterile part, but one with narrowed base 1 cm in diam; spore print white; basidiocarp with fruity aroma.

Hyphal system dimitic; contextual generative hyphae hyaline, thin-walled, occasionally branched, with conspicuous clamps, 3-7 µm in diam; contextual skeletal hyphae hyaline, sinuous or contorted with frequent constrictions and swellings, with occasional branching, nonseptate, 2.5-7 µm in diam, moderately thick- to firm-walled, walls 0.5-0.7 µm thick, some long, unbroken segments traceable to a thin-walled generative hypha; tramal hyphae similar.

Cystidia or other sterile hymenial elements absent.

Basidia clavate, not seen with sterigmata, 24-37 x 8-10 µm, with a basal clamp.

Basidiospores cylindric, hyaline, smooth, thin-walled, negative in Melzer's reagent, 10-14 x 4.0-4.5 µm.

Type of rot: white rot of dead oak branches.

Type: Nabogame, Municipio Temosachi, Chihuahua, Mexico, 28°30'N, 108° 30'W, elev. 1800 m, on dead branch of live *Quercus chihuahuensis* Trel. (locally known as encino blanco), 30 July 1987, J.E. Laferrière No. 602 (Holotype, BPI; isotypes, ARIZ and XAL).

Polyporus tenuiparies is macroscopically similar to *P. alveolaris* (DC.: Fr.) Bond. & Sing. However, *P. alveolaris* has extremely thick-walled, dendritically branched skeletal hyphae that are generally uniform in diameter and not sinuous as are those of *P. tenuiparies*. No other species of *Polyporus* is reported to have skeletal hyphae like those of *P. tenuiparies*.

ACKNOWLEDGMENTS

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NEW AND INTERESTING SPECIES OF CLADONIA FROM CALIFORNIA

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SUMMARY

In this paper six species in the lichen genus *Cladonia* are discussed. Four new and unreported taxa are treated in addition to two unusual chemical variants. This paper treats taxa to be included in sect. *Clausae* subsect. *Thallostelides* in the sense of Thomson. Two new species, *C. dimorpha* Hammer, and *C. prolifica* Ahti and Hammer are described. Additional taxa new to California are *C. cornuta* subsp. *groenlandica* and *C. verruculosa*. Morphologically interesting chemical variants of *C. cervicornis* and *C. humilis* are also reported. Speciation in *Cladonia* and its relationship to the phytogeography of California are considered.

INTRODUCTION

Extensive collecting and study of herbarium specimens of *Cladonia* Hill *ex* Browne (Ascomycotina: Lecanorales) has yielded several undescribed and unreported taxa from California. Two undescribed species, *C. dimorpha* Hammer and *C. prolifica* Ahti and Hammer are introduced in this paper. Two taxa, *C. cornuta* subsp. *groenlandica* (E. Dahl) Ahti and *C. verruculosa* (Vainio) Ahti, are previously unreported from California. The latter two taxa were not reported by Tucker and Jordan (1979) or Hale (1989). In addition, morphologically and chemically unusual specimens of *C. humilis* (With.) Laundon and *C. cervicornis* (Ach.) Flotow are reported. All of the species discussed in this paper can be included in sect. *Cladonia* subsect. *Cladonia* (see Huovinen et al. 1990). The species in this group were treated in Thomson (1968) under sect. *Clausae* subsect. *Thallostelides* (Vainio) Matt. (nom. illeg.). In California, sect. *Cladonia* is a large and diverse group that comprises over half of the *Cladonia* taxa in the state (Hammer 1988). The species discussed in this paper share morphological affinities with various distinct groups of sect. *Cladonia*. They reflect the phytogeography of the genus *Cladonia* in California, which is characterized by worldwide species but which includes several locally endemic taxa.

The vascular plant flora of California is noted for its large number of endemic species. Native phanerogamic species with worldwide distributions are rare in California (Raven and Axelrod 1978). The significant endemism of the vascular plant flora reflects the diversity of soils and climatic conditions in the state. By contrast, the lichen flora of California and adjacent regions is considered to consist of relatively few endemic species. Lichen species with putative worldwide distributions are quite common in California (Hale 1989), but recent collections in numerous localities indicate that speciation in *Cladonia* may be occurring at the level of population. In at least one *Cladonia* species in California, *C. cervicornis*, factors of azonal soil and reproductive isolation have produced distinct chemotypes within populations (Hammer 1989c). Of approximately 35 *Cladonia* species in California (Hammer 1988), only *C. transcendens* (Vainio) Vainio, *C. thiersii* Hammer (Hammer 1989a) and *C. prolifica* Ahti and Hammer are presently thought to be restricted to western North America.

Distributional trends in lichens are as yet poorly understood. Both vicariance and long-distance dispersal can be invoked to explain the presence of worldwide species in California (Yoshimura 1968; Kärnefelt 1980). Most of the species of *Cladonia* in California were described by Thomson (1968) as primarily boreal in their distribution, and new findings (Hammer 1989b) partly support this. Other studies indicate that many taxa previously considered boreal actually possess a bipolar distribution in the Western Hemisphere (Ahti and Kashiwadani 1984), as well as in disjunct localities such as New Zealand (Galloway 1985) and Melanesia (Stenroos 1988). In many species, a very large amplitude of variability is observed among populations from isolated localities, and a wide species concept is necessarily adopted. Nevertheless, one is daunted by concepts that favor worldwide species when studying specimens that appear to be distinct and locally endemic in California.

The taxa described in this paper reflect the wide morphological and chemical diversity that is characteristic of sect. *Cladonia*. Several distinct lineages of this poorly understood group are sympatric in California. The species discussed in this paper represent various informally recognized groups, viz.: "chlorophaea" (*C. humilis*), "verticillata" (*C. cervicornis* and *C. verruculosa*), and "gracilis" (*C. cornuta* subsp. *groenlandica*). As discussed below, the affinities of *C. dimorpha* and *C. prolifica* are not fully understood. Assuming that vicariance is the dominant factor in the worldwide distribution of these lineages, we may infer that they are quite old, and that evolution at what has been traditionally considered the subsectional level in *Cladonia* has been in force at least as long as it has for many phanerogamic plant families. The discovery of several new *Cladonia* species from California implies that, in spite of conservative evolutionary trends (Hawksworth 1982) and widespread disjunctions at the species level, there has been considerable local speciation in western North America.

MATERIALS AND METHODS

Several thousand collections of *Cladonia* were examined from fresh material and herbarium specimens over a three year period. Specimens were studied for morphological and chemical characters. Chemical analyses were performed by routine chemical spot tests (White and James 1985) and thin layer chromatography (TLC). Solvent systems "A" and "B" were used (Culberson 1974; Culberson et al. 1981; White and James 1985). The specimens cited in this paper, unless otherwise designated immediately following the specimen number, are deposited at FH.

Cladonia cornuta subsp. **groenlandica** (E. Dahl) Ahti

Ann. Bot. Fennici 17: 221. 1980.— *Cladonia cornuta* var. *groenlandica* E. Dahl, Meddel. Grønland 150(2): 100. 1950. — *Cladonia groenlandica* (E. Dahl) Trass, Folia Cryptog. Estonica 1:2. 1972. —Type: Greenland. Julianehaab District: Agdluitsoq (Lichtenaufjord), Sletten, 1937 *E. Dahl* (O, holotype and isotype).

Primary thallus squamulose, persistent or disappearing, the squamules 2-7 mm long, 2-4 mm wide, irregularly incised, crenate-lobate to digitately lobed, sinuate edged, sometimes with crenulate tips, dark greenish to olivaceous above, ventral surface white, flattened or involute, esorediate. *Podetia* arising from upper side of primary thallus, light greenish-gray to light brown, subcylindrical, 16-55 mm tall, up to 3 mm wide, unbranched or sparingly branched from scyphus margins, regularly scyphus-bearing with no subulate apices, bases persistent, cortex persistent at base and continuing 1/3 to 2/3 the distance to first scyphus, sometimes higher, rarely present on outer surface of scyphus, becoming longitudinally rugose, intermixed with distinct soralia, soralia breaking into diffuse masses of soredia, or with irregular, erumpent, coarse soralia or small corticated structures becoming increasingly frequent toward apices, soredia farinose, sometimes coarser; scyphi to 5 mm in diam, shallow, closed, inner surface corticated, turning dark brown, margins entire or with short dentate proliferations not exceeding 3 mm, or with one or more proliferations of scyphus-bearing stipes, cortex on proliferations like that of podetia, giving rise to soralia and later soredia. *Apothecia* borne on marginal proliferations, reddish brown, less than 1 mm in diam, *ascospores* and *asci* not observed.

On soil or growing over compressed duff.

Spot test reactions: K- or K+ dingy yellow changing to dingy brown, KC-, P+ brick red.

Chemical constituent: fumarprotocetraric acid.

Specimens studied: Del Norte Co.: *Hammer* 2151 (SFSU), *Ahti & Norris* 42512 (H), *Tucker* 6450 (H); Mendocino Co.: *Hammer* 1517 (SFSU).

Ahti (1980b) treated differences in podetial stature and scyphus development between subsp. *cornuta* and subsp. *groenlandica* as a problem of "two separate races with varying rhythms of development." A more difficult problem arises when comparing *C. ochrochlora* Flörke with *C. cornuta* subsp. *groenlandica* in northern California, where they are sympatric. The differences between them are subtle, but several factors may be helpful in distinguishing these taxa from one another. Their ecology appears to be somewhat different, with *C. cornuta* subsp. *groenlandica* favoring soil or compressed duff as substrata. *Cladonia ochrochlora* grows on rotting wood that is frequently wet. This substratum usually retains its moisture content between rains. When *C. ochrochlora* appears to be growing on bare soil, the substratum is usually buried wood that is partially rotten. Ahti (1980a) distinguished *C. cornuta* from *C. ochrochlora* partly on the basis of the consistency and thickness of the stereome (inner medullary layer). He stated that the stereome of *C. cornuta* was thin and relatively easily cut with a razor blade compared with *C. ochrochlora*. This test is not conclusive in every specimen. In that paper, *Cladonia ochrochlora* was mistakenly described as possessing longitudinal ridges in the cortex. Rather, both subspecies of *C. cornuta* characteristically possess longitudinal ridges, and they are most effectively distinguished from *C. ochrochlora* on this basis. Finally, the hyphae of the outer medulla and the scyphus interiors of *C. cornuta* subsp. *groenlandica* tend to become brown early in the ontogeny of the podetium, whereas these components appear white or off-white even in older specimens of *C. ochrochlora*. *Cladonia cornuta* subsp. *groenlandica* is distinctly circumboreal, with both amphiatlantic and amphipacific distributions (Ahti 1980a). Thomson (1968) and Ahti (1980a) indicated that subsp. *cornuta* is found in the northern and southern hemispheres, but subsp. *groenlandica* has not yet been reported from the southern hemisphere.

Cladonia verruculosa (Vainio) Ahti

Bryologist 81: 336. 1978.— *Cladonia pityrea* II. [=var.] *verruculosa* Vainio, Acta Soc. Fauna Fl. Fenn. 10:355. 1894 (called 'v. *verruculosa*' on p. 358).— Type. British Columbia: Vancouver Island, 1858-59 *Lyall*. (UPS, isosyntype, as *C. gracilis*).

Primary thallus squamulose; persistent or more usually disappearing. *Podetia* from primary squamules, 16-65 mm tall, to 2 mm wide, subcylindrical, unbranched or sparingly branched dichotomously and laterally or rarely from scyphus margins, subulate, scyphus-forming, or rarely blunt, basal portions persistent or dying, esorediate or sparingly granulose sorediate; cortex continuous to verruculose at base, scattered and disappearing in older specimens, breaking up above basal portion into verruculae, becoming scattered in places, thickening elsewhere and appearing rugose, or giving rise to isidioid structures, plate-like podetial squamules, or sorediose structures; scyphi produced at apices, shallow, irregular, closed, 1.5 -3.0 mm wide, margins entire or with blunt, digitate proliferations, or proliferations elongating and bearing scyphi, proliferations also arising from centers of scyphi, rarely in consecutive series. *Apothecia* chestnut brown to darker, borne on scyphus margins, to 3 mm in diam, sometimes exceeding podetial support; *ascospores* 8 per ascus, hyaline, non-septate, ellipsoid, 4.0-5.0 x 13.5-16.0 µm. *Pycnidia* on scyphus margins, *conidia* hyaline, non-septate, straight to arcuate, 0.5-2.0 x 3.0-8.0 µm.

On soil on exposed roadcuts or under conifers, also found on stabilized sand dunes among short grasses.

Spot test reactions: K- or K+ dingy yellow changing to dingy brown, KC-, P+ brick red.

Chemical constituent: fumarprotocetraric acid.

Specimens studied: CALIFORNIA. Del Norte Co.: *Hammer* 2178 (SFSU), *Hammer* 2564, 3308, 3310, 3313, 3335, *Ahti & Norris* 42477 (FH, H, UC), *Riefner* 85-662 (private herbarium); Humboldt Co.: *Ahti & Norris* 42402 (FH, H), *Lindsay* 46 (WIS); Mendocino Co.: *Hammer* 1573, (SFSU); OREGON. Coos Co.: *Hammer* 3510; Curry Co.: *Hammer* 3379; Douglas Co.: *Hammer* 3467; Lane Co.: *Hammer* 3470, 3568.

Cladonia verruculosa is rare in California, but locally abundant on the stabilized sand dunes near Ft. Dick, Del Norte County. It was discussed by Ahti (1978) as an endemic species of west coastal British Columbia and the surrounding Pacific Northwest of the United States, and has been collected extensively by Hammer in Oregon, Washington, and Idaho. It was reported from southern Chile by Ahti and Kashiwadani (1984). Collections at H contain specimens from the Venezuelan Andes, where *C. verruculosa* is sympatric with *C. andesita* Vainio and *C. aleuropoda* Vainio. Both of these species are morphologically similar and sometimes difficult to distinguish from *C. verruculosa*. *Cladonia verruculosa* is frequently misidentified as *C. nemoxyna* (= *C. rei* Schaerer) in western North American herbaria. Many of these specimens agree with Thomson's (1968) description of the latter. Both species are characterized by poorly formed, narrow scyphi, a sometimes brownish cast to the podetium, and infrequent, variable soredia. *Cladonia verruculosa* is distinct from *C. rei* in its generally taller podetia, proliferations (usually subulate) from the center of the scyphi as well as marginal proliferations, and infrequent granular soredia interspersed with conspicuous plate-like podetial squamules. The most decisive character separating the two is the constant presence in *C. rei* of the *m*-depside homosekekaic acid, which is never present in *C. verruculosa*.

Cladonia dimorpha Hammer sp. nov. Fig. 1

Type: USA. CALIFORNIA: Humboldt Co., on thin soil over roadcut in grove of *Sequoia sempervirens*, Honeydew Road near Rockefeller Memorial Redwood Grove, (US Hwy. 101), 1988, *Hammer* 1130 (Holotype: FH, Isotype: SFSU, Photograph at H); contains fumarprotocetraric acid.

> *Thallus primarius squamosus, persistens vel evanescens, ad 5 mm longus usque ad 3 mm latus, esorediatus. Podetia scyphifera, demum elongata proliferaque (longitudine circ. 3 mm usque ad 55 mm), scyphi clausi, corticati aut verrucis sparsis corticati aut decorticati; cortex crassus, rimosus, squamulosus, cavitate scyphorum corticata vel squamulosa, margine scyphorum prolifero, prolificationes ipsae ascyphiferae, inequaliter subcylindricae, dichotome ramosae, fissis vel axillibus perviis, esorediosae. Apothecia fusca, in apicibus ramorum. Acidum fumarprotocetraricum continens.*

Primary thallus squamulose, squamules persisting or disappearing, 2-4 mm long, 1-3 mm wide, entire to subdigitately lobed; upper surface grayish-green to olivaceous, ventral surface white, darkening toward base, subfibrillose, esorediate, flattened or involute. *Podetia* from upper side of primary squamules, 3-55 mm tall to 8 mm wide beneath scyphi, ashy-white to glaucescent green, scyphus-forming, proliferations arising on scyphus margins, bases persistent or dying; cortex continuous or verruculose, verruculae giving rise to abundant, crowded, imbricating, plate-like podetial squamules, podetia flaring abruptly beneath scyphi; scyphi 4-10 mm wide, closed, shallow, deforming, corticated, later giving rise to peltate squamules, squamules disappearing or persisting and densely covering scyphus interiors; margins entire, bearing sessile pycnidia and apothecial initials with protruding trichogynes, or with abundant squamules; one (seldom more) proliferations arising on scyphus margin, proliferations to 40 mm tall to 5 mm wide, elongate and ± flattened at area of interface with scyphus, branching dichotomously from open axils, longitudinal openings forming on proliferations, corticated or partially to mostly decorticated with a few persisting squamules; cortex becoming thick, later chinky or verruculose, finally disappearing or giving rise to abundant squamules; apices open where two or more apothecia are located at apex, or closed, with one or two apothecia borne on terminal branchlets.

Apothecia brown to dark brown, borne in clusters or singly, 0.3-3.2 mm diam. *Ascospores* 8 per ascus, hyaline, non-septate, 4-5 x 10-16 µm, oblong ellipsoid to fusiform. *Pycnidia* brown, blunt or pointed, usually with a restricted base, 0.5-1.0 mm. *Conidia* hyaline, non-septate, 0.5-1.0 x 3.0-8.0 µm, straight to arcuate.

Anatomy: Primary squamules 190-250 µm thick; cortex 26-36 µm thick, of agglutinated, ± isodiametric cells, 12-23 µm in diam, algal layer 74-93 µm thick, medulla 90-120 µm thick, of loosely interwoven, irregularly arranged, sparingly to strongly branched, heavily encrusted hyphae, 2-4 µm wide. *Podetial wall* 116-144 µm thick, outer layer of closely agglutinated cells, 14-24 µm thick; exterior medullary layer (including algal layer) 26-63 µm thick, inner cartilaginous layer 74-116 µm thick, well delineated from outer medullary layer. *Hymenium* 48-52 µm thick, *subhymenium* 50-90 µm thick; *asci* clavate 37-44 µm long, 6-10 µm wide; *paraphyses* subcylindrical, branched, 37-50 µm long, 2-3 µm thick.

Terricolous over roadcuts and on sandy soil.

Spot test reactions: K+ dull brown to K-, KC-, P+ reddish to brick red.

Chemical constituent: fumarprotocetraric acid.

Specimens examined: CALIFORNIA. Amador Co.: *Hammer* 1331 (SFSU); Del Norte Co.: *Hammer* 1920, 1921 (SFSU); *Hammer* 2013, 2185, 2187, 2184 (WIS);

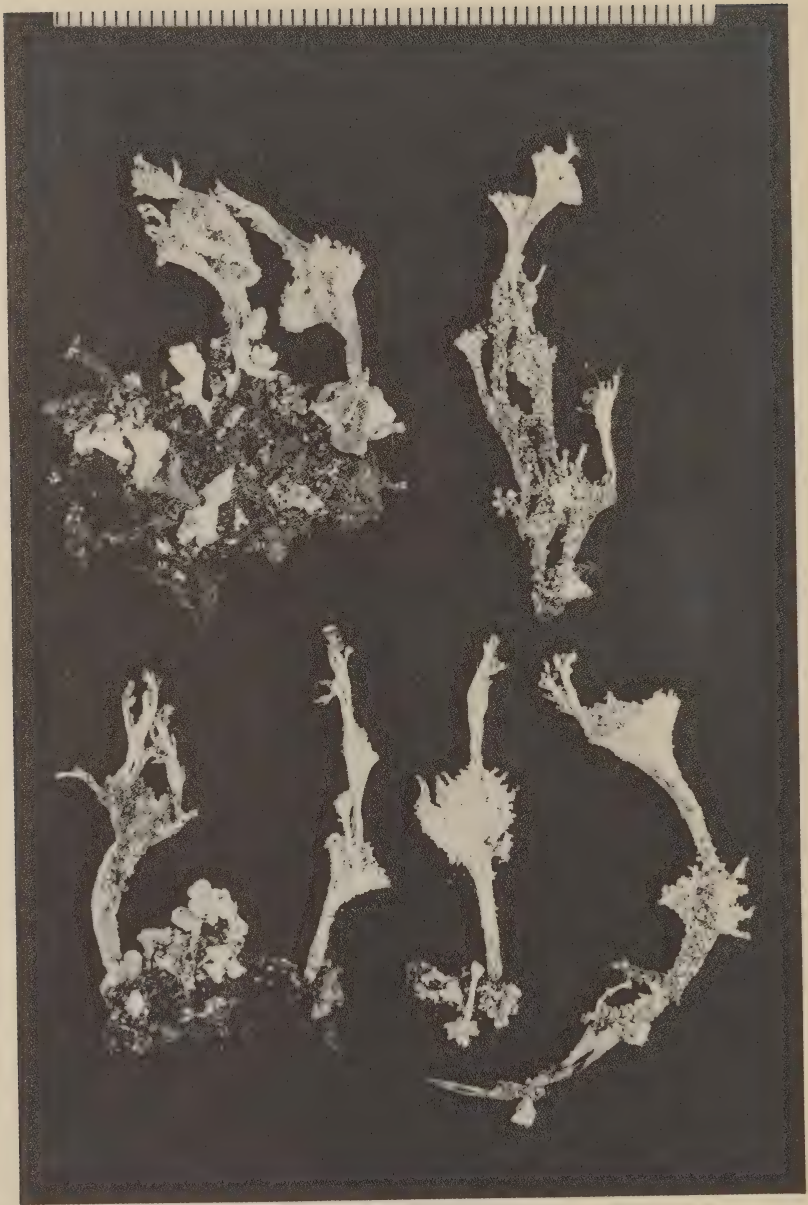

Fig. 1. *Cladonia dimorpha* sp. nov. *Hammer* 3284 (FH). Markings indicate 1mm.

Ahti & Norris 42471 (H); Humboldt Co.: *Hammer* 1104 (SFSU), 3262, 3290, 3293; Marin Co.: *Hammer* 1686 (US); *Hammer* 2025 (FH, CANL), *Koch* 366b (FH); Mendocino Co.: *Hammer* 786 (H); *Hammer* 788 (SFSU); *Hammer* 1008 (ASU); *Hammer* 1781, 1784, 1785, (SFSU); 1786 (NY), *Hammer* 1816, *Thiers* 49729 (SFSU); Shasta Co.: *Lund* s.n. (SFSU); OREGON. Curry Co.: *Hammer* 3372; Douglas Co.: *Hammer* 3443; WASHINGTON. Clallam Co: *Hammer* s.n.; BRITISH COLUMBIA. Rocky Point, Vancouver Island: *Savile* 251 (H); CANARY ISLANDS: *Follmann* 26282 (1980) (H).

Cladonia dimorpha is a fairly common species in northern California. It prefers shady areas, especially roadcuts, but has been collected in exposed localities as well. It resembles various taxa in subsect. *Cladonia*, notably *C. pyxidata* (L.) Hoffm., in the broad scyphi that are covered in the interior by peltate squamules, and *C. ramulosa* (With.) Laundon, in the scaly, esorediate cortex and the production of proliferations from scyphus margins. The most conspicuous diagnostic feature in mature specimens of *C. dimorpha* is the production of longitudinally fissured, hymenium-bearing proliferations that resemble the dichotomously branched podetia of *C. furcata* (Huds.) Schrad. At a glance, *C. dimorpha* approaches *C. pyxidata* with unusual marginal proliferations that resemble *C. furcata*. However, the scyphus-forming part of *C. dimorpha* is not corticated, thus excluding *C. pyxidata*. Even richly branched specimens of *C. dimorpha* retain a scyphus and thus cannot be confused with *C. furcata*.

The longitudinally fissured branches appear to be a determinate phase in the development of *C. dimorpha* since they do not produce further scyphi but always bear apothecia. In some specimens from California (*Hammer* 3262, 3290, 3293) scyphus-bearing podetia give rise to further series of scyphi. Only pycnidia and apothecial initials bearing abundant trichogynes have been observed along the scyphus margins in these specimens. Hymenial discs are not formed at this stage. They are borne at the apices of the proliferations, where there are no pycnidia or trichogynes. In some respects, this pattern of fertile, branching proliferations borne on sterile scyphus margins is similar to the pattern seen in *C. multiformis* Merr. Further anatomical studies are in progress on *C. dimorpha*, in which patterns of podetial formation and apothecial development will be studied, and possible relationships with *C. multiformis* analyzed. The precise affinities of *C. dimorpha* in sect. *Cladonia* are not yet clear. *Cladonia dimorpha* possesses characteristics of both sect. *Cladonia* and sect. *Perviae* (Fr.) Matt., under which *C. furcata* and *C. multiformis* have traditionally been placed. Ahti (1982) offered a provisional change in the subsectional classification within *Cladonia*, proposing a new group in which subsect. *Cladonia* (=subsect. *Thallostelides*) and series Furcatae were united. The morphology of *Cladonia dimorpha* substantiates the concept that the two groups are closely related.

Cladonia dimorpha characteristically contains fumarprotocetraric acid, but specimens that are morphologically similar show some variability in chemistry. The specimen from British Columbia (*Savile* 251) contains an unknown fatty acid, and the Canary Island material (*Follmann* 26282 contains protocetraric acid, Cph-2, as well as two unknown terpenes and two unknown fatty acids. Hammer (1988) treated *C. dimorpha* as *C. ramulosa* because of its superficial resemblance to the illustration of the latter in Laundon (1984). It was distributed as *C. ramulosa* to various herbaria. The subsequent comparison of extensive collections of *C. ramulosa* (=*C. pityrea* and vars.) at FH and H indicated that *C. dimorpha* is a distinct species.

Cladonia prolifica Ahti & Hammer sp. nov. Fig. 2.
Type: USA. CALIFORNIA: Amador Co., On duff of *Arctostaphylos myrtifolia* over lateritic soil derived from Ione Formation oxisol, Old Lambert Rd., Ione. 1988. Hammer 1265, Holotype: FH; Isotypes, H, NY; contains fumarprotocetraric acid.

> *Thallus primarius squamosus, persistens vel evanescens, ad 8 mm longus usque ad 4 mm latus, esorediatus. Podetia scyphifera, demum elongata proliferque (longitudine circ. 5 ad 35 mm), scyphi clausi, corticati; cavitate scyphorum corticata, margine scyphorum prolifero, prolificationibus ipsae ascyphiferis, tumido-obovatis, esorediosis. Apothecia fusca, in apicibus ramorum. Acidum fumarprotocetraricum continens.*

Primary thallus squamulose, persisting or evanescent, 2-8 mm long, 1-4 mm wide, sinuous to crenately lobed, subdigitate in well developed specimens, more or less orbicular; upper surface glaucescent green, sometimes with bluish tinge, becoming olivaceous to brown, ventral surface white, becoming brown at the edges and blackening toward base, subfibrillose, esorediate, flattened or involute. *Podetia* from upper surface of primary squamules, to 3.5 cm tall, to 4 mm wide, bone-white to pale glaucescent green, sometimes becoming bronze or brownish, subcylindrical, scyphus-bearing, slender at base and broadening gradually toward scyphi, unbranched, bases persistent and not blackening; scyphi formed on all podetia 6-10 mm from base, scyphi to 5 mm wide, 2-3 mm deep, closed, regular, interiors corticated, deforming, becoming shallow and oblique, margins crispate, bearing (10)-15-21 subdigitate, blunt, flexuous proliferations and abundant squamules; proliferations tipped with clusters of pycnidia, one (rarely two or more) proliferations elongating and thickening, finally becoming tumid-obovate with surface facing interior of scyphus generally ± flattened, bearing clusters of hymenial discs; hymenia conglomerating at apices into one or more rounded, tube-like structures, sometimes interspersed with tiny squamules, usually surrounding a secondarily open apex.

Apothecia dark reddish-brown to castenaceous, 1-3 mm wide, usually exceeding width of podetial support, *ascospores* 8 per ascus, hyaline, non-septate, 3.5-5.5 x 11.5-20.0 µm, fusiform to oblong-ellipsoid, *pycnidia* dark brown to black, often immature and pale, blunt or ± pointed, constricted at the base, 0.5-1.0 mm tall, conidia hyaline, non-septate, 0.5-1.0 x 5-8 µm, straight to falcate, usually thinner at apices.

Anatomy: Primary squamules 100-140 µm thick, cortex 20-30 µm thick, of agglutinated, isodiametric cells, cortex cells 8-10 µm diam, algal layer 20-40 µm thick, indistinct from lower medullary layer, lower medullary layer 40-70 µm thick, of closely interwoven hyphae, heavily encrusted with indistinct extracellular material; podetial wall 180-235 µm thick, cortex 7.5-17.5 µm thick, of agglutinated, subglobose to isodiametric cells, cortex cells 7.0-8.0 µm diam, outer medullary layer (including algal layer) 62.5-87.5 µm thick, inner medullary layer 87.5-130.0 µm thick, consisting of irregular bundles of thick-walled, agglutinated, longitudinally-oriented hyphae. *Hymenium* 45-55 µm thick; *asci* 42-45 x 10-12 µm, clavate, apex ca 11 µm thick, *paraphyses* subcylindrical, unbranched, 1-3 septate, 45-50 x 2-3 µm.

On duff of *Arctostaphylos myrtifolia* Parry over acidic (pH 2.9-4.0) soil derived from oxisol. Also on thin soil over stabilized sand dunes under *Pinus contorta* Dougl. *ex* Loud., and on siliceous outcrops.

Spot test reactions: K- yellowish to dingy brown, KC-, P+ brick red.

Chemical constituents: Fumarprotocetraric acid with accessory protocetraric acid, Cph-2, unknown fatty acids and terpenes.

Specimens examined: CALIFORNIA. Amador Co.: *Hammer* 1268, 2059 (SFSU), 1277 (WIS, ASU), 1285 (US), 2070 (CANL), Del Norte Co.: *Hammer* 1994, 2153 (SFSU), 3317 (FH), *Ahti & Norris* 42363, 42365 (H); Humboldt Co.: *Sherman* 1412 (HSC), *Ahti et al.* 42328, 42329 (H); OREGON. Curry Co.: *Hammer* 3367;

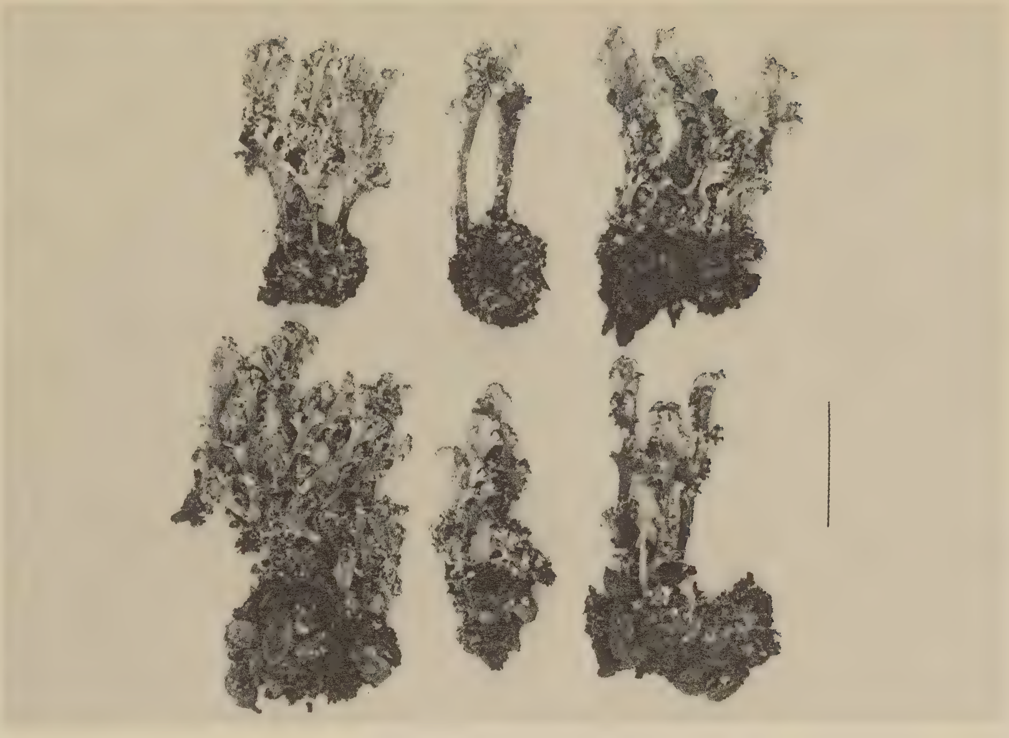

Fig. 2. *Cladonia prolifica* sp. nov. Holotype. Scale bar indicates 1 cm.

BRITISH COLUMBIA. Vancouver Island: *Ahti & Noble* 38577 (H), *Crane & Noble* 3979 (UBC), *L. & T. Ahti* 15317 (H); Denman Island: *Crane & Noble* 2530 (UBC); Saltspring Island: *Coursley & Noble* 2063 (UBC); Garibaldi Glacier: Fraser s.n. (UBC).

Cladonia prolifica is a locally variable species. Specimens from the type locality are characterized by a relatively thick cortex, persistent primary squamules with an occasional bluish tinge, and poorly developed proliferations on obliquely oriented, deformed scyphi. The podetia are usually greenish but occasionally they appear bronze. In these specimens, pycnidia are arranged more or less helically around a single (rarely more) proliferation. The population from which the type was collected is restricted to one site on an azonal lateritic soil (Singer and Nkedi-Kizza 1980). At this locality it grows on the duff of *Arctostaphylos myrtifolia*, an endemic shrub known only from scattered localities on Ione Formation soils in the foothills of the Sierra Nevada (Gankin and Major 1964, Stebbins and Major 1965). The population of *C. prolifica* at this locality is abundant and co-dominant with an unusual atranorin-containing population of *C. cervicornis* (Ach.) Flotow, which is described later in this paper.

Populations of *C. prolifica* from Humboldt County and Del Norte County are widely scattered and are usually collected over sandy soil near the Pacific Ocean or on somewhat acidic soil over roadcuts. They are usually found as isolated individuals, where they resemble poorly developed (and quite small) *C. gracilis* subsp. *turbinata* (Ach.) Ahti. *Cladonia prolifica* from these localities has been overlooked or misidentified as *C. phyllophora* Hoffm., to which it also bears a superficial resemblance. The cortex in *C. prolifica*, though not entirely continuous, is nevertheless persistent. This is in contrast to *C. phyllophora*, where a "corticoid" surface, similar to that found in subgen. *Cladina* (Nyl.) Leighton characterizes the podetium (Ahti 1978, Ruoss and Ahti 1988). The podetial bases of *C. prolifica* are persistent and non-blackening. By contrast, a distinct melanosis is observed in *C. phyllophora* on the surface and interior of podetial bases. Specimens of *C. prolifica* from British Columbia tend to produce numerous sterile, elongated proliferations along the scyphus margin, and the scyphi, though shallow, are barely deformed and generally not oblique as in the Amador County specimens. The full range of variability in *C. prolifica* has not been studied, nor have enough intermediate forms been collected, to allow a definitive discussion of the taxonomic status of its local variants. Like *C. dimorpha*, the exact affinities of *C. prolifica* have not yet been determined. Hammer (1988) treated *C. prolifica* as *C. phyllophora* because of its superficial resemblance to the latter, and distributed it as such to various herbaria.

Cladonia cfr. **humilis** (With.) Laundon

Lichenologist 16:220. 1984. —*Lichen humilis* Withering, Bot. Arrang. 721. 1776.
See Laundon (1984) for synonymy and typifications.

Primary thallus squamulose, persistent, 7-12 mm long, 3-8 mm wide, entire to irregulary crenate-lobate to shallow subdigitately lobate; upper surface glaucescent green to olivaceous, ventral surface white to ashy, darkening toward base, veins appearing toward base, subfibrillose, flattened to involute, wrapping around podetia in some and sometimes appearing cyathiform, esorediate or with granular soredia forming beneath margins. *Podetia* from upper side of primary squamules, 3-10 (20) mm tall, unbranched, scyphus forming; cortex lacking from base, or with immediate basal area corticated, granulose soredia (80-200 μm diam), appearing immediately above base, giving rise to small peltate squamules and isidioid structures, rarely enlarging to form podetial squamules, exposed inner layer impellucid, white to brownish, surface barely fibrillose; scyphi 1-8 mm in diam, closed, shallow, frequently with punctiform opening in center of scyphus interior, abundantly covered with granulose soredia and peltate squamules, enlarging and deforming with age, margins producing numerous (5-23) digitate proliferations, apices of proliferations blunt or expanding to form scyphi, rarely giving rise to further proliferations.

Apothecia borne singly along scyphus margins or at tips of proliferations, 120-200 µm in diam, dark reddish brown, *asci* and *ascospores* not observed.

On thin soil within 1 km of the Pacific Ocean.

Spot test reactions: K+ yellow, persistent, KC-, P+ orange, changing to red.

Chemical constituents: atranorin, bourgeanic acid, fumarprotocetraric acid, and protocetraric acid.

Specimens studied: CALIFORNIA. Marin Co.: *Hammer* 2023 (FH, H), 2372 (FH).

Cladonia humilis s. str. is not uncommon in California, and has been collected in both coastal and inland localities from Santa Barbara County to Del Norte County (Hammer 1988). It is characterized by the regular production of scyphi with entire margins, a corticated base, and farinose soredia on the outer layer of the scyphi. Atranorin is a regular component of its chemistry, along with fumarprotocetraric acid. The specimens cited above differ from *C. humilis* in several respects, including their deep scyphi with numerous proliferations, quite large (80-200 µm), granular soredia that give rise to isidioid structures and peltate squamules, large, persistent, veined primary squamules, and the presence of bourgeanic acid. The combination of these features applies neither to *C. humilis* s. str., nor to the recently described *C. humilis* var. *bourgeanica* A. W. Archer (Archer 1989). The cyathiform primary squamules of these unusual specimens approach *C. cyathomorpha* Stirt. *ex* Wats., and their overall morphology is comparable to numerous specimens from E and O, including the type. However, these specimens lack the characteristic unknown compound that characterizes *C. cyathomorpha* (Jølle 1977).

The presence of bourgeanic acid in *C.* cfr. *humilis* allies it with the complex of species in the *C. chlorophaea* group that possess fatty acids as diagnostic substances (Ahti 1966; Holien and Tønsberg 1985). The biogenetic pathway for bourgeanic acid and other fatty acids diverges early in the formation of constituent chemicals in this group according to Culberson (1986) and Huovinen and Ahti (1982). Nourish and Oliver (1976) did not report the presence of atranorin with bourgeanic acid in either *C.* "*conista*" (=*C. humilis* var. *bourgeanica*) or *C.* "*conistea*" (=*C. humilis* var. *humilis*). Ahti and Kashiwadani (1984) and Ferraro and Ahti (1987) reported specimens of *C. humilis* containing bourgeanic acid with atranorin and fumarprotocetraric acid from Chile and Argentina. The morphology of these specimens more closely approaches that of *C. humilis* s. str. than do the California specimens discussed above.

Cladonia cfr. **cervicornis** (Ach.) Flotow

Jber. Schles. Ges. vaterl. Cult. 27:31 (1849). Lichenologist 12:126. 1980. — *Lichen cervicornis* Acharius, Lich. Suec. Prodr.:184. 1799 ('1798'); type: Sweden (H-ACH 1672 B-C, BM-ACH 722A-syntypes; cf. Ahti 1980b).

Primary thallus squamulose, persistent, 3-6 mm long, 2-5 mm wide, entire to ligulate, irregularly digitate lobate; upper surface greenish to olivaceous, becoming brownish with age, sometimes with bluish tinge, ventral surface white, darkening with age, involute, esorediate. *Podetia* arising from upper surface of primary squamules, 14-40 mm tall, to 2 mm wide, subcylindrical, simple to sparingly laterally branched, scyphus-bearing, persisting or dying at base; cortex continuous to subcontinuous, thinning above base, sometimes appearing thicker under scyphi or inside scyphi, sparingly squamulose, esorediate; podetia barely thickening beneath scyphi; scyphi 1-3 mm wide, interiors closed, margins entire, often with abundant squamules; one (rarely more) tier of scyphus-bearing proliferations arising from center of scyphi, proliferations bearing hymenia or pycnidia. *Apothecia* light brown to reddish brown or darker, to 3.5

mm in diam, borne individually or in clusters around margins of scyphi or on proliferations, usually inconspicuous, sometimes growing larger than podetial support; *ascospores* 8 per ascus, hyaline, non-septate, ellipsoid, 4.5-5.0 x 10.0-16.0 µm, *conidia* hyaline, non-septate, straight to arcuate, 0.5-1.0 x 3.0-4.0 µm.

Terricolous on acidic Ione Formation soil, or over duff of *Arctostaphylos myrtifolia* Parry, also on sandstone.

Spot test reactions: K+ yellow, quickly becoming dingy yellow and finally brownish, KC-, P+ brick red.

Chemical constituents: fumarprotocetraric acid, protocetraric acid, Cph-2, atranorin, and unknown terpenes.

Specimens studied: CALIFORNIA. Amador Co.: *Hammer* 1160, 1271, 1280, 1317, 1769, 2079, 2080; Santa Barbara Co.: *Bratt* 6390 (FH, SBM).

Cladonia cervicornis is easily recognized by its successive tiers of proliferations, which usually arise from the center of its scyphi. Specimens with persistent primary squamules and frequently abundant posetial squamules are referred to *C. cervicornis* (Ach.) Flotow subsp. *cervicornis*. In most of northern and coastal California, the species contains fumarprotocetraric acid only. In the population from Amador County, ca 75% of the podetia that were tested by TLC contained atranorin in addition to fumarprotocetraric acid. The problem of atranorin-containing populations of *C. cervicornis* on azonal, acidic soils in California was discussed by Hammer (1989c). Morphological differences between the Amador County population and other populations of *C. cervicornis* in California were not discussed in that paper. The Amador County population is characterized by long, ligulate, persistent primary squamules often with a bluish tinge. The ventral side of the primary squamules usually blackens with age. The rather poorly developed podetia are quite narrow compared to other populations of *C. cervicornis* in California. The podetia from Amador County are usually olivaceous or brown, in contast to populations from other localities in which the podetia are usually glaucescent green, and which often possess a pinkish tinge in the exposed outer medullary layer. Multiple tiers of verticillate proliferations are common in *C. cervicornis* in western North America, but the Amador County population rarely has more than one proliferation per podetium. Scyphi in the Amador County population are rarely well developed, and seldom reach even 3 mm in width, in contrast with the scyphi of *C. cervicornis* that can reach 1 cm diam. The margins of the scyphi in the Amador County population typically bear abundant ligulate squamules, which are distinct from the crenately-lobed or incised squamules of *C. cervicornis* subsp. *cervicornis*. The podetia in this population are frequently recumbent, at least in part, in contrast to other specimens, where podetia are distinctly erect. The podetia that are recumbent are frequently laterally branched, a phenomenon that is very rare in *C. cervicornis*. Numerous specimens from southern California at SBM were previously referred to *C. cervicornis* (Hammer 1988) but recent studies indicate that they may be more closely allied to the Amador County population than previously thought. Further comparative studies are necessary to determine the taxonomic status of both of these aberrant populations.

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MYCOTAXON

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LINDTNERIA PANPHYLIENSIS SP. NOV. FROM PO VALLEY, ITALY

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While investigating the mycological flora of Panfilia Forest in Po Valley, Italy, Anarosa Bernicchia made several collections of an undescribed species of *Lindtneria*. The existing Panfilia Forest is only a remnant of the original forest ecosystem of the Po Valley. Today this forest is associated with a high water table and autumn and spring flooding. The habitat favors hydric vegetation, which is comprised primarily of *Quercus robur* L., *Populus alba* L., *Fraxinus angustifolia* Vahl., *Salix alba* L., *Ulmus minor* Mill., and *Acer campestre* L. Specimens of this *Lindtneria* species have been collected only in late winter or early spring, and always after the autumnal floods.

Data on microscopic characteristics were obtained from small portions of basidiocarps squash-mounted in 5 percent KOH (w/v) and stained with 1 percent Phloxine B (w/v), Melzer's reagent (Melzer 1924) or lactophenol cotton blue (Johansen 1940). Material was prepared for scanning electron microscopy (SEM) by rehydrating small pieces of sporophores in 10 percent KOH for 5 minutes, followed by sequential dehydration in 25, 50, 75, and 95 percent ethyl alcohol for 5 minutes at each concentration, and 100 percent ethyl alcohol for two changes at 5 minutes each, critical point dried, and gold coated. Micrographs were taken with a Hitachi[1] S530 scanning electron microscope at an accelerating voltage of 25 kV. Capital letters used to designate herbaria are those of Holmgren _et al_. (1981). Color designations are those of Munsell (1929-1942).

Lindtneria _panphyliensis_ Bernicchia et M. Larsen, sp. nov. Fig. 1

Basidiocarpis effusis, papillosis vel odontoideis, pallidoluteis vel ochraceis; basidiis 20-25 x 9-11 µm, tunicatis cyanophyliis; cystidiis 4.5-6 µm diam., plus minusve claviformis vel subulatis; hyphis subiculis saepe inflatis subsphaericis, 8-12 µm latis, incrustatis; basidiosporis (7-) 7.5-8.0 (-10) x 4.5-6 µm, fusoideo-ellipsoideis, verrucatis, pallidoluteis vel ochraceis, cyanophyliis, nonamyloideis.

Holotypus--Italy, Panfilia Forest (Ferrara), on _Quercus pedunculata_, 6 II 1986, A. Bernicchia no. 4080 (CFMR).

BASIDIOCARP: Effuse, up to 25 mm thick, occurring in small patches, readily separable, fragmenting when touched, pelliculose, some parts pellucid and parchment-like. HYMENIAL SURFACE: Papillate to odontoid to less frequently smooth, pale yellow to buff-yellow to pinkish buff (near 10.0 YR 8/6 to 10.0 YR 7/6). MARGIN: Arachoid to farinaceous, paler than the hymenial surface. CORDONS: Barely discernible at 10X. SUBICULAR HYPHAE: 2.5-5 µm diam, septate with clamp-connections at some septa, frequently swollen and constricted at septa, often in the form of roughly subspherical cells, which give rise to as many as five radiating hyphae (these subspherical cells as well as hyphae are usually encased in a noticeably refractory material imparting a thick-walled appearance), thin-walled, hyaline, IKI-, some parts distinctly cyanophilous in cotton blue. CORDONS: Up to 25 µm diam, composed of exterior hyphae 2.5-3 µm diam., septate with ? clamp connections at some septa, and core hyphae up to

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[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

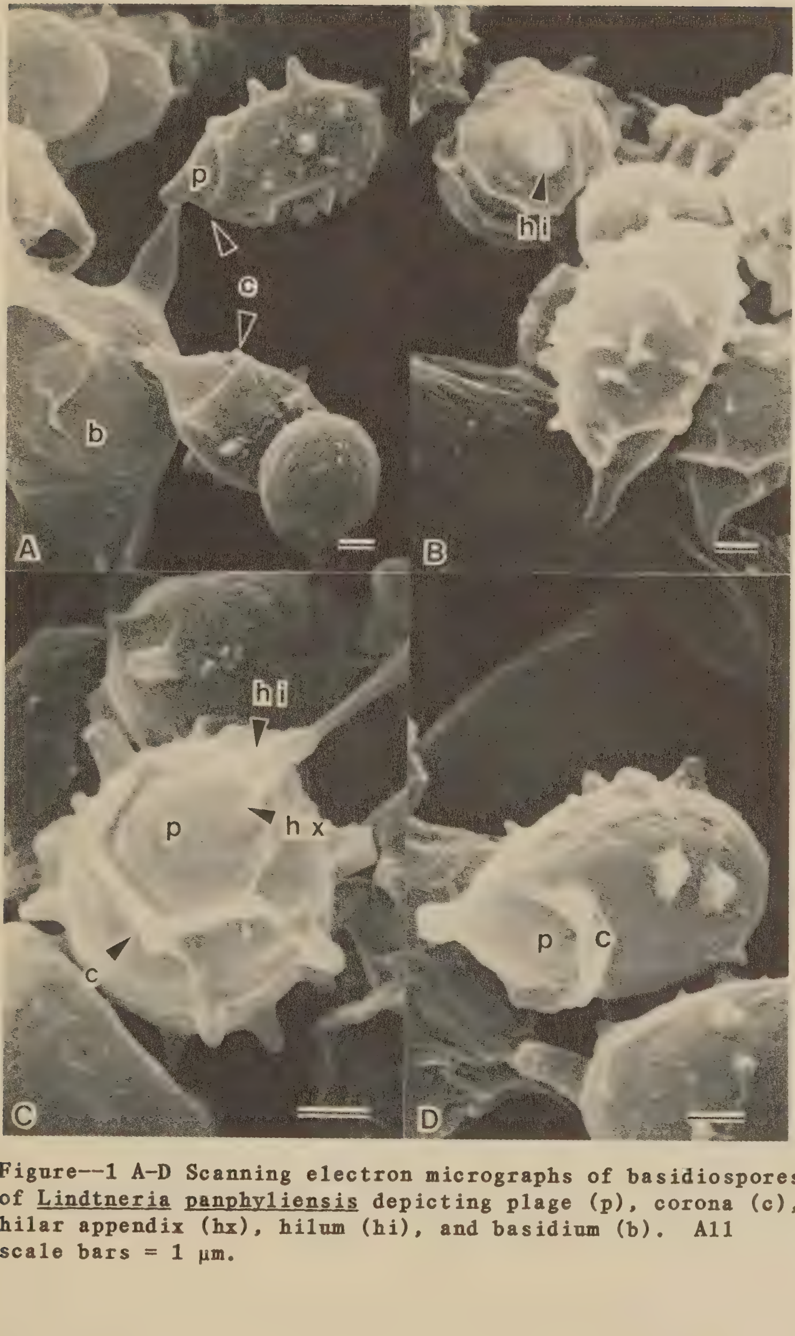
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Figure--1 A-D Scanning electron micrographs of basidiospores of Lindtneria panphyliensis depicting plage (p), corona (c), hilar appendix (hx), hilum (hi), and basidium (b). All scale bars = 1 µm.

20 µm diam, hyaline and septate. SUBHYMENIAL HYPHAE: 4-5 µm diam, intricately branched, closely septate with clamp connections occurring at some septa, encrusted in part with refractory material, some parts cyanophilous, IKI-. BASIDIA: 20-25 x 9-11 µm, clavate, frequently with a median constriction, clamps not observed at the basal septum, 4-sterigmate, often pluriguttulate, IKI-, cyanophilous. BASIDIOSPORES: (7-) 7.5-8.0 (-10) x 4.5-6 µm, fusoid-ellipsoid, often flattened slightly on one side, hilar appendix up to 1 µm long, with small warts scattered irregularly over the spore surface, pale yellow, cyanophilous, IKI-, plaque and corona or collar barely discernible at 100 x bright field, with SEM corona intimately associated with the hilar appendix but not distinctly fused.

Specimens examined: Italy, Panfilia Forest (Ferrara), on (?) _Quercus_ sp., 23 IV 1986, A. Bernicchia no. 4069; on (?) _Populus_ sp. 6 II 1986, A. Bernicchia no. 4706; on _Quercus pedunculata_, 6 II 1986, A. Bernicchia no. 4079; on _Q. pedunculata_, 6 II 1986, A. Bernicchia no. 4080 (Holotype). All specimens filed in herbarium CFMR.

Remarks--_Lindtneria panphyliensis_ is characterized by its papillose to odontoid hymenophore, encrusted swollen subicular hyphal cells, and fusoid-ellipsoid basidiospores. The lack of fusion of the corona or collar with the hilar appendix may be of taxonomic significance, for in other species of _Lindtneria_, continuity of these two structures has been demonstrated (Larsen 1986).

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REEXAMINATION OF THE NOMENCLATURAL TYPES OF POLYPORUS RIMOSUS BERK. AND P. BADIUS BERK.

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ABSTRACT

Recent interpretations of the names Phellinus rimosus and P. badius are reviewed. The extant type material of P. rimosus was found to contain two different Phellinus species. Thus, P. rimosus is retypified, and an earlier name, Polyporus igniarius var. scaber (=Phellinus scaber), is used for the second species. Phellinus badius appears to be misapplied in a variety of senses, and, as proposed earlier, its application is restricted to the nomenclatural type.

Kotlaba and Pouzar (1978), upon reviewing the Phellinus rimosus complex, concluded that the application of the name P. badius (Berk.) Pilat should be restricted to the nomenclatural type. Furthermore, they lectotypified P. rimosus from available type material at K. The typification of P. rimosus is questioned as well as the application of the names P. rimosus and P. badius.

Data on microscopic characteristics were obtained from freehand vertical sections of basidiocarps mounted in 2 percent (w/v) KOH and stained with 1 percent (w/v) Phloxine B, Melzer's reagent (IKI) (Melzer 1924) and cotton blue (Johansen 1940). Herbarium designations are from Holmgren et al. (1981).

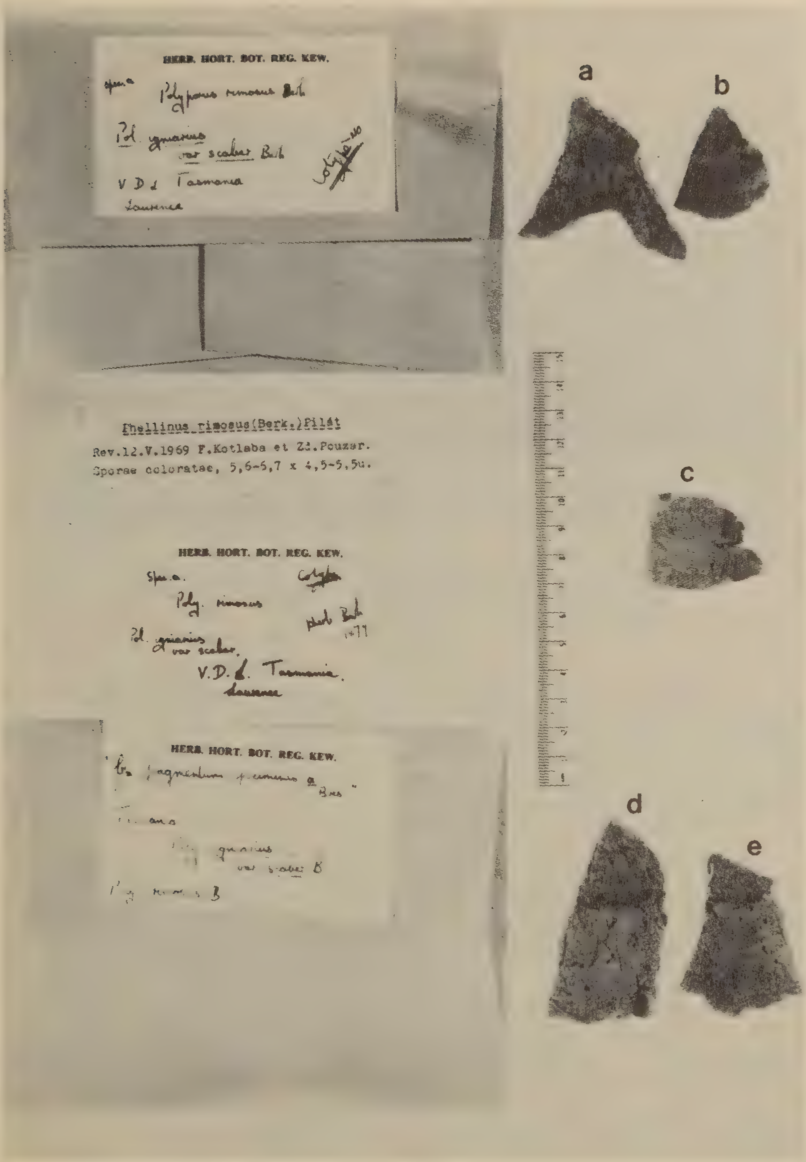
PHELLINUS RIMOSUS

Berkeley described P. rimosus twice, first as Polyporus igniarius var. scaber Berk. (Berkeley 1839) and second as Polyporus rimosus Berk. (Berkeley 1845). In 1845, he treated P. igniarius var. scaber as a synonym of P. rimosus. My searches through Berkeley's polypore collections at K did not yield material collected by Drummond from Australia that could serve as type of P. rimosus. Nevertheless, two specimens referred to in the description of var. scaber--one from Tasmania (Van Diemen's Land), which has been distributed among three separate packets, and one from Mauritius--are extant. The individual pieces of the two collections could be partly and precisely reassembled, thereby providing additional information on the size and shape of the respective basidiocarps. However, one of the Tasmanian packets contains a portion of a different collection representing a different species. Bresadola (1913), Lloyd (1915), Cunningham (1965), and Ryvarden (1976) concluded that the Tasmanian specimen is the type. Kotlaba and Pouzar (1978) accurately described the macroscopic and microscopic characteristics of what is referred to here as piece "c" (Fig. 1,2) and is accompanied by their dated annotation. Piece "c" is not related in any way to specimen pieces "a, b, d, e" (Fig. 1). In the other two Tasmanian packets, piece "c" is part of the specimen represented by pieces f-h (Fig. 2) in the packet from Mauritius. Therefore, Kotlaba and Pouzar's (1978) descriptive data for Phellinus rimosus were derived from the Mauritius rather than the Tasmanian collection. Further confusion concerning the packet containing piece "c" is encountered by the occurrence of a specimen "shadow" (caused by gluing portions of specimens to small pieces of paper). This "shadow" does not match piece "c" but instead matches piece "d," suggesting strongly that this portion had been moved. Ryvarden (1976) concluded that the specimens in question represented the same species, which is probably correct if he saw only pieces of the Mauritus collection.

Lowe (1957), Cunningham (1965), Ryvarden (1976), and Ryvarden and Johansen (1980) indicate that they examined the same lectotype from Tasmania. However, from their published information, it is not possible to determine if these authors actually looked at the Tasmanian specimen or were misled by the errant portion of the Mauritius specimen. Lloyd (1915, p. 249, Fig. 598) illustrated what he called

ERRATA, VOLUME THIRTY-SEVEN

Page	354	line	24	*for*	(Fig. 1). In	*read*	(Fig. 1) in
			25	*for*	packets, piece	*read*	packets. Piece



HERB. HORT. BOT. REG. KEW.
Spec.a Polyporus rimosus Berk
Pol. igniarius var scaber Berk
Cotype
V D L Tasmania
Lawrence

Phellinus rimosus(Berk.)Pilát
Rev.12.V.1969 F.Kotlaba et Zd.Pouzar.
Sporae coloratae, 5,6-6,7 x 4,5-5,5u.

HERB. HORT. BOT. REG. KEW.
Spec. a. Cotype
Poly. rimosus
Herb Berk 1877
Pol. igniarius var scaber.
V.D.L. Tasmania.
Lawrence

HERB. HORT. BOT. REG. KEW.
"[illegible] fragmentum speciminis a Bres"
[illegible]
[illegible] igniarius var scaber B
Poly rimosus B

Figure 1 a-e--Type material of Polyporus igniarius var. scaber from Tasmania showing relative distribution of specimen pieces among packets (K).

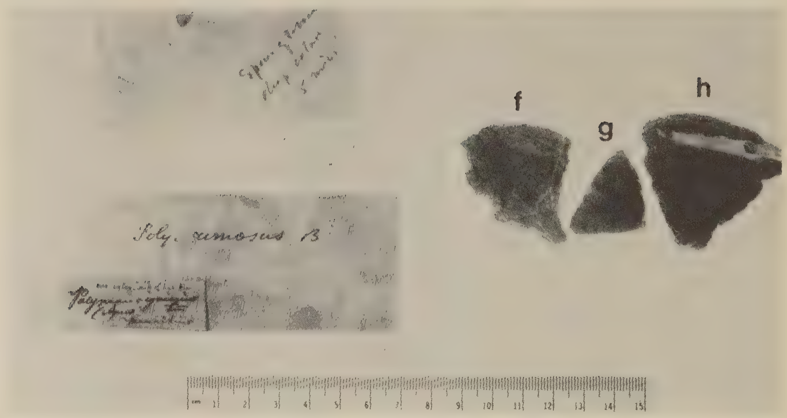


Figure 2 f-h--Type material of Polyporus igniarius var. scaber from Mauritius (K).

Fomes scaber (Berk.) Lloyd, based on a portion of the Tasmanian collection. This same portion is illustrated here as Figure 1a. Lloyd (1915) further ventured that the Mauritius specimen actually represented what had become widely known as Fomes rimosus.

Lloyd's (1915) interpretation is worthy of further consideration, especially in light of the absence of the original protologue for P. rimosus and Kotlaba and Pouzar's (1978) inadvertent lectotypification of P. rimosus with the Mauritius specimen. I propose that the Tasmanian collection be used to typify Polyporus igniarius var. scaber Berk. and that the Mauritius specimen be used as type for Polyporus rimosus Berk. Descriptions of the respective lectotypes and associated nomenclators follow.

Phellinus scaber (Berk.) M. Larsen, comb. nov.

= Polyporus igniarius var. scaber Berk., Ann. Nat. Hist. 3:324. 1839 (Basionym).

= Fomes scaber (Berk.) Lloyd, Mycol. Writ. 4:249. 1915.

Lectotype--Tasmania (Van Diemen's Land), host unknown, coll. Lawrence (K). The specimen is represented by pieces a, b, d, e (Fig. 1).

BASIDIOCARP: (Partly reassembled) approximately 6-7 x 9-10 x 6 cm, strongly ungulate, perennial, indurate; UPPER SURFACE: Dull brownish gray to grayish black, cracking irregularly and becoming somewhat fissured, forming irregular plate-like scales and conspicuous in older portions; MARGIN: Obtuse, thick; HYMENIAL SURFACE: Mostly concave, in part irregular and undulate; PORE SURFACE: Dull chocolate brown, pores 5-6 per mm, round, TUBE LAYERS: Variable in length (0.5-2.0 cm), separated by a well defined black tissue layer. PRIMARY AND SECONDARY CONTEXT: Dull rusty brown, woody, with many fine black lines.

PRIMARY CONTEXT HYPHAE: Skeletal 5-7 µm diam, septate and with many adventitious septa, wall thickening noticeable, pale to dull brown, often irregular in form; contextual chlamydospores 10-14 x 7-10 µm, (?) terminal and intercalary, thick-walled, dark brown; generative 2.5-3 µm diam, branched, septate, pale yellowish to dull brown. SECONDARY CONTEXT HYPHAE: Skeletal apparently absent; generative 6-8.5 µm diam, parallel, frequently branched and septate, somewhat thick- to thin-walled, pale brown. TRAMAL HYPHAE: a mixture of somewhat parallel arranged generative and skeletal hyphae; skeletal hyphae 5-7.5 (-8) µm diam, thick-walled, with some adventitious septa present; generative hyphae 2-4 µm diam, frequently septate and branched, pale brown. SETAE: Not seen. BASIDIA: Not seen. BASIDIOSPORES: 7-7.5 (-7.7) x (5.0-) 5.5-6 µm, broadly ellipsoid to subglobose, eventually becoming thick-walled, pale yellowish brown to brown in KOH, hyaline to pale yellowish brown in IKI and H_2O.

Phellinus rimosus (Berk.) Pilat., Ann. Mycol. 38:80. 1940.

= Polyporus rimosus Berk., London J. Bot. 4:54. 1845.

= Fomes rimosus (Berk.) Fr., Nov. Symb., p. 66. 1851.

= *Fomes rimosus* (Berk.) Cke., Grevillea 14:18. 1885 (*nom. superf.*).

= *Scindalma rimosus* (Berk.) O. Kuntze, Rev. Gen. Plant 3:519. 1898.

= *Xanthochrous rimosus* (Berk.) Pat., Essai Tax., p. 101. 1900.

= *Phellinus rimosus* (Berk.) Bond. et Sing., Ann. Mycol. 39:56. 1941 (*nom. superf.*).

Lectotype--Mauritius, host, collector and date unknown (K). The specimen is represented by pieces c, f, g, and h (Fig. 1,2).

BASIDIOCARP: (Partly reassembled) ungulate, perennial, broadly attached to the substrate, hard and woody, 6 x 3.5 x 4.5 cm; UPPER SURFACE: Rimose, deeply fissured and cracked and separating into course thick scales that are arranged somewhat concentrically, becoming brownish black, forming a distinct black pellicle approximately 0.1 mm thick; margin narrow and abrupt; PORE SURFACE: Dark ferruginous brown to umber, plane to slightly convex, pores 4-6 per mm, round, mostly slightly dentate; TUBE LAYERS: Indistinctly stratified, individual layers 2-4 mm thick, pale ferruginous brown, these becoming stuffed with pale brown mycelia. PRIMARY CONTEXT: Somewhat zonate, pale ferruginous brown with some very faint pale colored streaks; SECONDARY CONTEXT: Not well developed, appearing concolorous.

PRIMARY CONTEXT HYPHAE of three kinds: Skeletal, 2.5-3 µm diam, arranged parallel, thick-walled, infrequently branched, some secondary septa present, dark brown, often with protuberances that resemble clamp connections; generative 2-2.5 (-3) µm diam, septate, branched, pale yellowish brown; binding 2-3 µm diam, aseptate, thick-walled, conspicuously and intricately branched, dark brown. SECONDARY CONTEXT HYPHAE: Poorly developed, skeletal 4.5-5.5 µm diam, arranged parallel, thick-walled, septa infrequent, dull brown; generative 2-2.5 µm diam, septate, thin-walled, pale tan. TRAMAL HYPHAE: Skeletal 4-5 µm diam, thick-walled, adventitious septa frequent, dark brown, arranged parallel; generative 2.5-3 µm diam, septate, pale tan, thin-walled. SETAE: Not seen. BASIDIA: Not seen. BASIDIOSPORES: 6-6.5 x 4.5-5.5 µm, broadly ellipsoid to ovoid to subglobose, becoming thick-walled, dull brown in KOH, pale yellow brown in H_2O, darkening slightly in IKI.

Remarks--The revised concept of _P_. _rimosus_ proposed here differs from that projected by Kotlaba and Pouzar (1978), Cunningham (1965), and other authors. The former concept of _P_. _rimosus_ was predicated on a series of misidentifications. I examined numerous collections named _P_. _rimosus_, which cannot presently be identified with any certainty with the Tasmanian or Mauritius lectotypes. _Phellinus_ _badius_ _sensu_ Gilbertson _et_ _al_. (1976) and Gilbertson and Ryvarden (1987) do not fit this concept, an opinion that is contrary to that of Kotlaba and Pouzar (1978). Lowe (1957) and Cunningham (1965) indicate that the Mauritius specimen represents _P_. _badius_, but I disagree with this conclusion as does Ryvarden (1976).

PHELLINUS BADIUS

Phellinus _badius_ (Berk. ex Cke.) G. H. Cunn. New Zealand Dept. Sci. Ind. Res. Bull. 164:233. 1965.

= _Polyporus_ _badius_ Berk., Ann. Mag. Nat. Hist. 7:453. 1841 (_nom_. _illeg_., _non_ _P_. _badius_ [Pers.] Schw. 1832).

= _Fomes_ _badius_ Berk. ex Cke., Grevillea 14:18. 1885.

= _Trametes_ _badia_ (Berk. ex Cke.) Pat., Essai, p. 93. 1900.

= _Polystictus_ _badius_ (Berk. ex Cke.) Lloyd, Mycol. Notes 65:1038. 1921.

= _Phellinus_ _badius_ (Berk. ex Cke.) Ahmad, Monogr. Biol. Soc. Pakistan 6:55. 1972 (_non_. _superf_.).

Lectotype--North America, (Cunningham believes that this specimen is probably from the West Indies and not Arctic America as labeled.) "_Polyporus_ _badius_ n.sp. No. 6 Suberoso lignosi.
Dr. Richardson."

BASIDIOCARP: Perennial, ungulate, attached sublaterally and appearing somewhat pendant and narrowing to 2 x 4 cm at point of attachment; UPPER SURFACE: Glabrous, brownish black, indurate, appearing in cross section as a black line 0.2 mm thick; MARGIN: Obtuse, paler than the pilear surface but eventually concolorous, with extremely small (visible at 50X) resinous-like granules that barely protude above the pilear surface; PORE SURFACE: Flat, glancing slightly, dark brown, sterile margin narrow, pores 5-6 per mm, mostly angular with 4-5 sides; TUBE LAYERS: Up to 7 mm thick each, individual layers not distinct, pale ferruginous brown; PRIMARY CONTEXT: Dull yellowish brown tissue, somewhat zonate, hard; SECONDARY CONTEXT: Yellowish brown, growth orientation apparent, turning upwards to 90 degrees towards the pilear surface.

PRIMARY CONTEXT HYPHAE: Skeletal 4.5-5 (-5.5) µm diam, becoming thick-walled, dull brown, infrequently branched and septate, some secondary septa present; generative infrequent, 2-4 µm diam, septate, pale brown. SECONDARY CONTEXT HYPHAE: Skeletal 2.5-4.5 µm diam, thick-walled, ferruginous brown, infrequently branched, septa infrequent; generative not discernible. TRAMAL HYPHAE: Skeletal 2.5-3 (-4) µm diam, arranged parallel, dark ferruginous brown, adventitious septa and branching infrequent; generative 2-3 µm diam, pale yellow brown, frequently septate and branched. SETAE: Absent. BASIDIA: Not seen. BASIDIOSPORES: 7 (6.5-)-7.5 x 5.5-6 (-6.5) µm, broadly ovoid to subglobose, wall thickening noticeable to thick-walled, yellowish brown to dark brown in KOH, pale yellowish brown in H_2O, darkening in IKI but not dextrinoid (wall thickening more apparent in H_2O and IKI).

Remarks--Kotlaba and Pouzar (1978) concluded from their studies of the type of P. badius that the application of this name should be limited to the type, and I agree. A series of named collections of P. badius has been examined from various localities, including material that forms the basis of interpretations of Gilbertson and Ryvarden (1987), Gilbertson et al. (1976), and Lowe (1957), but none could be identified with certainty with the type of P. badius. Kotlaba and Pouzar (1978) referred material of these authors to P. rimosus.

ACKNOWLEDGMENTS

The curators of the Royal Botanic Gardens, Kew, particularly Dr. D.A. Reid, are gratefully acknowledged for their generous assistance during my recent stay.

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MYXOMYCETES OF ALBERTA

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ABSTRACT

This first paper on the Myxomycetes of Alberta lists collections and microhabitats for 71 species representing 26 genera. Collections are deposited in the University of Alberta Cryptogamic Herbarium, Edmonton (ALTA) or in the National Mycological Herbarium, Ottawa (DAOM).

INTRODUCTION

The province of Alberta has 12 major vegetation zones within an area of 661,185 km^2 that lies between 49° and 60° N latitude. Altitude varies from 600 m in the east to over 3,700 m in the Rocky Mountains along the southwestern boundary. The climate of the region is continental with an average annual rainfall of about 50 cm (Moss, 1983). Considering the diversity of habitats available in Alberta, a rich myxomycete biota would be expected. For the province of Manitoba, which is located within the same latitudes as Alberta, Bisby (1938) recorded 96 Myxomycete species. In the same volume he noted only six species from the neighbouring province of Saskatchewan. Cheesman (1911) listed 15 Myxomycetes from the province. An examination of the standard works on Myxomycetes (Hagelstein 1944, Martin and Alexopoulos 1969) reveals that only two collections are noted from Alberta among descriptions of more than 420 species.

Our study was undertaken to provide baseline data for future floristic and ecological investigations by verifying and compiling all available herbarium records of Myxomycetes collected in Alberta. We found a total of 71 taxa, a number which is comparable to the 87 taxa recently listed for the state of Arkansas (Eliasson, Keller and Hutchison, 1988). Because most of the collections in our list have been made in the vicinity of major population centres and parks, the list should be considered a minimum representation of the myxomycete biota of Alberta.

Specimens were obtained from the University of Alberta Cryptogamic Herbarium, Edmonton (ALTA), the National Mycological Herbarium, Ottawa (DAOM), and from personal collections. No moist chamber cultures were made with bark samples from living trees; our list therefore excludes corticolous species. Macroscopic features were studied using a stereoscopic microscope. Mounts were prepared by placing a fragment of a mature fruiting body onto a slide, wetting with 95% ethanol, and mounting in lactophenol. Specimens having calcareous structures, which react with the acidic lactophenol, were mounted in distilled water. Microscopic details were studied using a phase-contrast microscope. Ranges noted for spore dimensions are averages rounded to the nearest 0.1 um and are based on 25 spores measured under oil immersion (x1000). Collection information was taken directly from herbarium packets. Additional information is added in square brackets. Nomenclature follows Martin and Alexopoulos (1969) except where noted.

CERATIOMYXALES

Ceratiomyxa fruticulosa (Mull.) Macbr., N. Am. Slime-Moulds. 18. 1899.

ALTA 5: A. Stewart (s169), Devonian Botanic Garden, Devon, on rotten decorticated *Picea* log. ALTA 6: J. States, July 30, 1967, Sandy Lake, on *Populus* log. ALTA 7: J. States, July 16, 1967, Long Lake Provincial Park, on wood. ALTA 8: J. States and R. Larcade, Conjuring Creek, W of Edmonton, [on bark]. ALTA 8506: K. Richardson (KR18), July 8, 1988, Devonian Botanic Garden, Devon, on decaying wood. ALTA 8511: K. Richardson (KR25), July 18, 1988, Sundre, on wood.

LICEALES

Cribraria argillacea (Pers.) Pers., Neues Mag. Bot. 1: 91. 1794.

DAOM 176837a: G.P. White, Aug. 5, 1980, Cameron Lake, Waterton National Park, on rotting wood piled in swamp.

Cribraria cancellata (Batsch) Nann.-Brem., Nederlandse Myxomyceten 92. 1974.

ALTA 4696: D. Yaremchuk, July 15, 1972, 4 miles W of Myrnam, [on dead wood]. ALTA 8524: K. Richardson (KR54), Aug. 14, 1988, Emily Murphy Park, Edmonton, on moist decaying log. ALTA 8545: R. Currah (RC83-31), July 20, 1983, Devonian Botanic Garden, Devon, on wood. DAOM 176948: G.P. White (#844), Aug. 13, 1980, Crandell Lake Trail, Waterton National Park, on rotting *Pinus* log in *Pinus* forest.

Dictydium cancellatum in Martin and Alexopoulos.

Cribraria oregana H. C. Gilbert, in Peck and Gilbert, Amer. Jour. Bot. 19: 142. 1932.

DAOM 176810: G.P. White (#706), Aug. 4, 1980, Red Rock Canyon, Waterton National Park, on fallen *Picea* branch in *Picea-Pinus* forest.

This specimen was deposited as *Cribraria* sp. by G.P. White. It is placed here under *Cribraria oregana* because of its dull ochraceous color, minute size and deeply cupulate calyculus with a persistent net. Martin and Alexopoulos described the spores of this species as having a delicate reticulum but this feature was not observed on the spores of this specimen.

Cribraria purpurea Schrad., Nov. Gen. Pl. 8. 1797.

ALTA 48: L. Kennedy, Oct. 1956, Edmonton, on conifer wood. ALTA 101: L. Kennedy, Oct. 1, 1965, Edmonton, on wood. *Metatrichia vesparium* (q.v.) also present.

Cribraria rufa (Roth) Rost., Mon. 232. 1875.

DAOM 176984: G.P. White (#880), Aug. 15, 1980, Waterton National Park, on rotting *Pinus* log in *Pinus* woods.

Enteridium splendens (Morgan) Macbr. N. Am. Slime-Moulds. 151. 1899.

ALTA 17: M. Ostafichuk, May 28, 1965, bog W of Edmonton, on burned *Picea mariana*. ALTA 19: L. Kennedy, Aug. 1, 1965, Spruce Grove, on *Populus* log. ALTA 20: L. Kennedy, Sept. 5, 1965, Edmonton, on wood. ALTA 23: L. Kennedy, Oct. 2, 1963, Edmonton, on *Populus* log. ALTA 42: L. Kennedy (#460), Oct. 10, 1953, Edmonton, on wood. ALTA 3740: R. Edwards, Sept. 7, 1969, Lacombe, on *Betula* bark. ALTA 4104: J. States, Sept. 11, 1968, Conjuring Creek, [on wood]. ALTA 4862: S. Campbell, Oct. 2, 1971, Magnolia, [on bark with moss]. ALTA 8469: R. Danielson (RMD1149c), Aug. 29, 1973, Fish Creek Provincial Park, Calgary, on *Populus* log in *Salix-Populus-Amelanchier* stand. ALTA 8478: R. Danielson (RMD1696), Aug. 27, 1975, Yamnuska, Seebe, on *Populus* bark. ALTA 8480: R. Danielson (RMD1771), Sept. 9, 1975, Yamnuska, Seebe, on *Populus* log. ALTA 8529: K. Richardson (KR60), Sept. 4, 1988, Wates-Gibson Hut, Tonquin Valley, Jasper National Park, on log.

Reticularia splendens in Martin and Alexopoulos. ALTA 42 had been deposited as *Enteridium lycoperdon*, but because the cortex of this specimen is silvery rather than brownish and because the pseudocapillitium is thin and web-like rather than dendroid, the specimen clearly belongs in *E. splendens*. ALTA 8529 differs slightly from the other specimens placed in *E. splendens* in that the spores appear spinulose rather than reticulate.

Licea fimicola Dearness and Bisby, in Bisby, Buller and Dearness, Fungi Manit. 52. 1929.

ALTA 7482, 7486: N.P. Hyduke, Oct. 11, 1976, Badlands near Wardlow, off Route 876, on old cow dung from grazed area. [In moist chamber].

Licea tenera Jahn, Ber. Deutsch. Bot. Ges. 36: 665. 1919.

ALTA 7484, 7485: N.P. Hyduke, Oct. 18, 1976, in grazed Badlands SW of Wardlow, on old cow dung. [In moist chamber].

Lindbladia tubulina Fries, Summa Veg. Scand. 449. 1849.

ALTA 8449: R. Danielson (RMD300), Aug. 13, 1972, Marmot Basin Creek in Kananaskis Valley, about 50 miles W of Calgary, elevation 5500 feet, on rotten wood and litter in *Picea glauca* stand.

Lycogala epidendrum (L.) Fries, Syst. Myc. 3: 80. 1829.

ALTA 29: L. Kennedy, Sept. 22, 1953, Stony Plain, on *Populus* wood. ALTA 35: L. Kennedy, Oct. 15, 1953, Edmonton, on wood. ALTA 36: E.H. Moss, Sept. 20, 1933, Edmonton, on wood. ALTA 37: A. Stewart, Sept. 11, 1963, Whitecourt, on wood. ALTA 40: J. Dugle, Aug. 29, 1962, Camp #2, Kananaskis, on wood. ALTA 4695: J. Traquair, Aug. 6, 1971, Elk Island National Park, on wood. ALTA 4698: B. Wong, Aug. 16, 1971, Pembina River Provincial Park, on rotten *Betula* log. ALTA 4855: J. Traquair, Aug. 4, 1971, [on wood] near bridge over North Saskatchewan River, Highway 47, E of Drayton Valley. ALTA 7746: H.M. Schalkwyk, Sept. 25, 1978, Rainbow Valley, Edmonton, on wood. ALTA 7750: H.M. Schalkwyk, June 11, 1978, Sandy Lake, on old wood. ALTA 8071: W. Wong, July 6, 1972, Carson Lake, on *Populus balsamifera* log. ALTA 8440: R. Danielson (RMD117), July 1, 1972, Brown-Lowery Provincial Park, on log (*Picea*?). ALTA 8441: R. Danielson (RMD140), July 20, 1972, Glenmore Park, Calgary, on rotten log. ALTA 8474: R. Danielson (RMD1609), July 8, 1975, Sheep River, on rotten *Salix* lying across a small spring in *Picea* stand. ALTA 8499: K. Richardson (KR10), June 10, 1988, Elk Island National Park, Moss Trail, on fallen *Betula* log in shaded area. ALTA 8504: K. Richardson (KR16), July 19, 1988, Devonian Botanic Garden, Devon, on wood (*Arcyria nutans* (q.v.) also present). ALTA 8507: K. Richardson (KR19), July 10, 1988, Kinsman Park, Edmonton, on dead tree trunk. ALTA 8514: K. Richardson (KR32), July 25, 1988, Wates-Gibson Hut, Tonquin Valley, Jasper National Park, on fallen log.

Lycogala flavofuscum (Ehrenb.) Rost., in Fuckel, Jahrb. Nassauischen Vereins Naturk. 27-28: 68. 1873.

ALTA 4778, 4779: J. Traquair, July 31, 1972, Healy Creek, Banff National Park, Highway 1, [on bark]. ALTA 4840: J. States, Aug. 20, 1967, Cardinal River, [on wood]. ALTA 8452: R. Danielson (RMD611), March 4, 1973, Fish Creek Provincial Park, Calgary, on bark of fallen moss covered *Picea* log. ALTA 8462: R. Danielson (RMD1050), Aug. 19, 1973, Fish Creek Provincial Park, Calgary, on top of log, Area 35, *Populus-Picea* stand. ALTA 8466: R. Danielson (RMD1068), Aug. 21, 1973, Fish Creek Provincial Park, Calgary, on dead heartwood of living *Populus balsamifera*. ALTA 8468: R. Danielson (RMD1149b), Aug. 29, 1973, Fish Creek Provincial Park, Calgary, on *Populus* log in *Salix-Populus-Amelanchier* stand. ALTA 8470: R. Danielson (RMD1328), Sept. 23, 1973, 82nd Street, Calgary, on wet, rotten *Populus* stump in *Populus* stand.

Several collections (ALTA 4778, 4779, 4840) of *L. flavofuscum* had been deposited as *Enteridium lycoperdon*. These species can be easily differentiated because *L. flavofuscum* has a constricted base, a thick cortex and small spores, (5-6 um), whereas *E. lycoperdon* has a broad base, a thin cortex and larger spores, (8-9 um).

Tubifera ferruginosa (Batsch) J. F. Gmel., Car. Linn. Syst. Nat. 2: 1472. 1791.

ALTA 3682: P. Seymour, Aug. 8, 1969, Medicine Lake, Jasper National Park, [on wood]. DAOM 176959: G.P. White (#855), Aug. 14, 1980, Cameron Lake, Waterton National Park, on rotten *Abies* log along trail.

TRICHIALES

Arcyria cinerea (Bull.) Pers., Syn. Fung. 184. 1801.

ALTA 70: L. Kennedy (#464), Nov. 1, 1953, Edmonton, on *Populus*. ALTA 4078: A. Stewart, Oct. 7, 1964, Edmonton, on *Populus*. ALTA 4080, 4105: growing on *Bjerkandera adustus* basidiocarp in Univ. of Alberta lab. ALTA 8460: R. Danielson (RMD1009), Aug. 13, 1973, Wyndham Park near Carseland, on rotten *Populus balsamifera* log. ALTA 8486: R. Danielson (RMD1970), June 3, 1976, Cypress Hills, on rotting *Populus tremuloides* log. ALTA 8496 (2 boxes): K. Richardson (KR7), developed in moist chamber on decaying wood from Kinsman Park, Edmonton.

Arcyria denudata (L.) Wettst. Verh. Zool.- Bot. Ges. Wien 35: Abh. 535. 1886.

ALTA 64: L. Kennedy, Sept. 23, 1953, Stony Plain, on *Populus* log. ALTA 4095: L. Kennedy, Aug. 1960, Edmonton [on wood]. ALTA 4111: P. Seymour, Oct. 8, 1964, Edmonton, on *Populus* log. ALTA 4860: C. Strand, July 28, 1971, W of Forestry Reserve along river bank, Edmonton, [on wood]. ALTA 8534: K. Richardson (KR66), Sept. 23, 1988, Edmonton, on decaying tree stump with *Comatricha typhoides* (q.v.).

Arcyria ferruginea Sauter, Flora 24: 316. 1841.

ALTA 60: L. Kennedy, Oct. 6, 1953, Edmonton, on *Populus* wood. ALTA 62: A. Stewart, Sept. 15, 1961, Cameron Lake, Waterton National Park, on rotten wood.

Arcyria incarnata (Pers.) Pers., Obs. Mycol. 1: 58. 1796.

ALTA 66: R. Hnatiuk, Oct. 1966, Edmonton, on dead tree stump. ALTA 4070: Sept 30, 1968, Edmonton, on wood. ALTA 4071: Sept 30, 1968, Edmonton, on wood. ALTA 4838: C. Strand, Sept. 30, 1968, along North Saskatchewan River bank by Forestry Reserve, on wood. ALTA 8465: R. Danielson (RMD1065), Aug. 21, 1973, Fish Creek Provincial Park, Calgary, on *Populus balsamifera* log, partly covered by moss. ALTA 8471: R. Danielson (RMD1439), July 26, 1974, Fort McMurray, in *Populus* stand.

Arcyria obvelata (Oeder) Onsberg, Mycologia 70: 1286. 1978.

ALTA 8459: R. Danielson (RMD1008), Aug. 13, 1973, Wyndham Park near Carseland, on rotten *Populus balsamifera* log. ALTA 8503: K. Richardson (KR14), July 8, 1988, Devonian Botanic Garden, Devon, on dead wood with *Lycogala epidendrum* (q.v.).

Arcyria nutans in Martin and Alexopoulos.

Arcyria oerstedtii Rost., Mon. 278. 1875.

ALTA 7487: L. Kennedy, Sept. 11, 1975: Edmonton river valley bank, on *Populus* log.

Arcyria pomiformis (Leers) Rost., Mon. 271. 1875.

ALTA 8505: K. Richardson (KR17), July 8, 1988, Devonian Botanic Garden, Devon, on wood.

Hemitrichia clavata (Pers.) Rost., in Fuckel, Jahrb. Nassauischen Vereins Naturk. 27-28: 75. 1873.

ALTA 80: L. Kennedy (#584), Aug. 23, 1956, Edmonton, on *Populus* log. ALTA 82: A. Stewart (s16), May 16, 1963, Edmonton river valley, path E of meadow, on fallen log (*Populus*?) with moss. ALTA 85: L. Kennedy (#456), Oct. 8, 1953, Edmonton, on wood. ALTA 87: D. States (#94b), Sept. 17, 1967, Freeman River, 20 miles NW of Fort Assiniboine, on *Picea* log. ALTA 88: D. States (#54a), Aug 16, 1967, Long Lake Provincial Park SW shore, on *Populus* log. ALTA 89: D. States (#54b), Aug. 5, 1967, Upper Brown Creek Crossing, Chungo Road, [on wood]. ALTA 94: L. Kennedy, Oct. 24, 1956, Edmonton, on *Populus* log. ALTA 95: L. Kennedy (#461), Oct. 15, 1953, Edmonton, on wood. ALTA 96: E.H. Moss (#6431), Oct. 9, 1942, Edmonton, on wood. *Trichia decipiens* (q.v.) also present. ALTA 4074: L. Kennedy, Oct. 2, 1963, Edmonton, on *Populus balsamifera*. ALTA 4084: C. Strand, Sept. 30, 1968, Edmonton river valley, on fallen wood. ALTA 4112: Sept. 26, 1968, Edmonton. ALTA 4774: J.A. Traquair (T140), Aug. 4, 1970, E of Drayton Valley, [on wood]. ALTA 4837: B. Schweger, Oct. 15, 1972, near Winterburn, on wood. ALTA 7906: L. Kennedy, Sept. 14, 1979, Edmonton, on deciduous wood. ALTA 8487: R. Danielson (RMD1970), June 3, 1976, Cypress Hills, on rotten *Populus tremuloides* log. ALTA 8490: R. Danielson (RMD2295), Aug. 22, 1976, Nose Hill Park, Calgary, on rotten *Populus tremuloides* log with *Lycogala epidendrum* (q.v.). ALTA 8495: K. Richardson (KR6), May 18, 1988, Emily Murphy Park, Edmonton, on fallen *Betula* log. ALTA 8500: K. Richardson (KR11), June 10, 1988, Elk Island National Park, Moss Trail, on fallen *Betula* log in shaded area. ALTA 8502: K. Richardson (KR13), June 19, 1988, John Janzen Nature Centre, Edmonton, on damp rotting wood in shaded area. ALTA 8525: K. Richardson (KR55), Aug. 14, 1988, Emily Murphy Park, Edmonton, on old wood.

ALTA 96 was previously identified as *H. stipitata*. The distinction between *H. stipitata* and *H. clavata* is based in part on the size of sporangia and attachment of the capillitium, characters that are highly variable within our collections. ALTA 96 has broader sporangia than our other collections of *H. clavata*.

Metatrichia vesparium (Batsch) Nann.-Brem., Proc. K. Ned. Akad. Wet. C. 69: 146. 1966.

ALTA 75: E.H. Moss, Edmonton, on wood. ALTA 76: A. Stewart (s44), May 30, 1963, river valley in front of Biology building, U. of A., Edmonton, on rotten *Betula*. ALTA 77: A. Stewart (s24), May 16, 1963, river valley hillside, path E of meadow, Edmonton, on fallen *Betula* log. ALTA 78: A. Stewart (s17), May 16, 1963, river valley, path E of meadow, Edmonton, on north side of moist fallen log. ALTA 79: A. Stewart (s19), May 16, 1963, river valley E of meadow, Edmonton, on fallen *Picea*. ALTA 101: L. Kennedy, Oct. 1, 1965, Edmonton, [on wood (*Cribraria purpurea* (q.v.) also present]. ALTA 102: D. States (#84), Sept. 10, 1967, Pembina River Provincial Park, in *Populus-Picea* forest. ALTA 104: R. Carefoot, May 5, 1958, Edmonton, on rotten wood. ALTA 105: R. Hnatiuk, July 1966, Wapiti Campground, Jasper National Park, on wood. ALTA 3683: J. States, Aug. 1967, Sandy Beach, [on wood]. ALTA 4772: L. Kennedy, Oct. 4, 1972, Blackmud Creek, Edmonton, [on wood]. ALTA 4775: B. Wong, Aug. 4, 1971, near Warburg, on wood. ALTA 4777: C. Strand, July 28, 1971, along Forestry Reserve fence, river bank, Edmonton, [on wood]. ALTA 8494: K. Richardson (KR5), May 18, 1988, Emily Murphy Park, Edmonton, on fallen *Betula* log. ALTA 8523: K. Richardson

(KR51), Aug. 4, 1988, Emily Murphy Park, Edmonton, on decaying *Betula* log. ALTA 8533: K. Richardson (KR65), Sept. 23, 1988, River Valley, Edmonton, inside decaying moist log.

Five collections (ALTA 75, 76, 77, 78, 79) had been deposited as *Arcyria oerstedtii*. Confusion may have been due to the fact that both *A. oerstedtii* and *Metatrichia vesparium* have capillitia with spines.

Perichaena corticalis (Batsch) Rost., Mon. 293. 1875.

ALTA 4075, 4076, 4077, 4079: L. Kennedy (#771), Sept. 12, 1966, Edson, on *Populus* log.

Trichia decipiens (Pers.) Macbr., N. Am. Slime-Moulds. 218. 1899.

ALTA 96: E.H. Moss (#6431), Oct. 9, 1942, Edmonton, growing on wood. [*Hemitrichia clavata* (q.v.) also present]. ALTA 113: L. Kennedy (#459), Oct. 10, 1953, Edmonton, on wood. ALTA 116: L. Kennedy, Oct. 3, 1965, Edmonton, on *Populus* log. ALTA 117: L. Kennedy (#462), Oct. 15, 1953, Edmonton, on *Populus* log. ALTA 4099: R. Hnatiuk, Aug. 1966, Grande Prairie, [on wood]. ALTA 8073: B. Wong (B165), Aug. 30, 1971, 26 miles N of Slave Lake on Wabasca Road, on moist decorticated *Populus* log. ALTA 8463: R. Danielson (RMD1052), Aug. 19, 1973, Fish Creek Provincial Park, Calgary, on rotten *Populus balsamifera* log partially covered with *Drepanocladus uncinatus*. ALTA 8516: K. Richardson (KR40), July 26, 1988, Wates-Gibson Hut, Tonquin Valley, Jasper National Park, on old coniferous log.

In some specimens, key characteristics varied from the descriptions given in Martin and Alexopoulos. In ALTA 117, the elaters have widely spaced, unevenly wound spirals. ALTA 4099 conformed in all respects with published descriptions except that the spores were not reticulate. Spore size as given in Martin and Alexopoulos ranges from 10 to 13 um, but in ALTA 116 spores were only 8-9 um.

Trichia favoginea (Batsch) Pers., Neues Mag. Bot. 1: 90. 1794.

ALTA 8453: R. Danielson (RMD694), May 19, 1973, Fish Creek Provincial Park, Calgary, on *Betula* log.

Martin and Alexopoulos described the spore size as being (12)13-15(16) um, and noted that a great range of variation exists. The spores of ALTA 8453 are at the extreme lower end of the scale.

Trichia scabra Rost., Mon. 258. 1875.

ALTA 86: A. Stewart (s33), May 21, 1963, ravine W of Storyland Valley Zoo, Edmonton, on moist rotten log. ALTA 109: C. Strand, Sept. 30, 1968, Edmonton, on *Populus balsamifera* log. ALTA 8456: R. Danielson (RMD793), June 21, 1973, Cominco Natural Area, Calgary, on underside of rotten *Populus balsamifera* log. DAOM 176885: G.P. White (#781), Aug. 8, 1980, Waterton National Park, on rotting *Populus* stump in *Populus* forest.

Trichia subfusca Rex, Proc. Acad. Nat. Sci. Philadelphia. 42: 192. 1890.

ALTA 115: R. Hnatiuk, July, 1966, Wapiti Campground, Jasper National Park, on wood.

Trichia varia (Pers.) Pers., Neues Mag. Bot. 1:90. 1794.

ALTA 84: L. Kennedy, Sept. 30, 1966, Edmonton, on *Populus* bark. ALTA 118: D. States (#85), Sept. 10, 1967, Pembina River Provincial Park, in *Populus-Picea* forest. ALTA 119: D. States (#80), Aug. 25, 1967, campsite 15 miles E of Robb, on *Populus* log. ALTA 4116: P. Seymour, Oct. 8, 1964, Edmonton, on *Populus* log. ALTA 8531: K. Richardson (KR62), Sept. 12, 1988, Edmonton river valley, in shaded area of moist decaying log. ALTA 8542: K. Richardson (KR75), Oct. 1, 1988, Hondo-Slave Lake area, in a cavity inside a decaying log.

STEMONITALES

Lamproderma arcyrioides (Sommerf.) Rost., Mon. 206. 1874.

ALTA 132: A. Stewart (s18), May 16, 1963, river valley path E of meadow on hillside, in a cavity inside fallen *Picea* log. ALTA 4085, 4086, 4101: L. Kennedy, Oct. 7, 1966, Blackmud Creek, Edmonton, on wood.

Lamproderma columbinum (Pers.) Rost., in Fuckel, Jahrb. Nassauischen Vereins Naturk. 27-28: 69. 1873.

ALTA 4089: R. Hnatiuk, Aug. 22, 1966, Wapiti Campground, Jasper National Park, on wood [scant material].

Paradiachea rispaudii (Hagelst.) Hertel, Dusenia 7: 349. 1956.

ALTA 125: R. Hnatiuk (#670098), Aug. 1966, Mount Hector, Banff, on *Menziesia ferruginea* twigs. *Diderma niveum* (q.v.) also present.

Comatricha rispaudii in Martin and Alexopoulos.

Paradiacheopsis acanthodes (Alexop.) Nann.-Brem. Proc. K. Ned. Akad. Wet. C. 70: 209. 1967.

ALTA 8489: K. Richardson (KR15), from moist chamber incubation (10 days), wood from decayed stump, Hoodoo trail, Banff National Park.

Comatricha acanthodes in Martin and Alexopoulos.

Stemonaria irregularis (Rex) Nann.-Brem., Sharma and Y. Yamam. Proc. K. Ned. Akad. Wet. C. 87: 456. 1984.

ALTA 8521: K. Richardson (KR49), July 28, 1988, Devonian Botanic Garden, Devon, on *Betula* bark.

Comatricha irregularis in Martin and Alexopoulos.

Stemonitis aequalis (Peck) Nann.-Brem. Proc. K. Ned. Akad. Wet. C. 70. 207. 1967.

ALTA 8493: K. Richardson (KR2), May 15, 1988, Kinsman Park, Edmonton, on underside of decaying wood fragment.

Comatricha aequalis in Martin and Alexopoulos.

Stemonitis axifera (Bull.) Macbr., N. Am. Slime-Moulds. 120. 1889.

ALTA 4061: L. Kennedy (#651), Aug. 10, 1961, Cameron Lake, Waterton National Park, [on wood]. ALTA 4062: R. Hnatiuk (#670378), Celestine Lake, Jasper, on *Pinus* twig. ALTA 4773: C. Strand, July 28, 1971, Edmonton, on *Betula*. ALTA 4857: B. Wong, July 28, 1971, W of Forestry Reserve N of river bank, on moss covered wood. ALTA 4858: B. Wong, Aug. 4, 1971, 3 miles N of Warburg, [on wood]. ALTA 8074: L. Kennedy, July 21, 1982, Hondo, site #6, on *Populus* log. ALTA 8457: R. Danielson (RMD880), July 17, 1973, Glenmore Natural Area, Calgary, on rotten *Populus tremuloides* log. ALTA 8464: R. Danielson (RMD 1063), Aug. 21, 1973, Fish Creek Provincial Park, Calgary, on rotten *Populus* log. ALTA 8472: R. Danielson (RMD1447), July 28, 1974, Fort McMurray, on rotten *Populus* log. ALTA 8488: R. Danielson (RMD2135), Aug. 7, 1976, Yamnuska, Seebe, on underside of *Populus tremuloides*. ALTA 8513: R. Currah (KR28), July 22, 1988, Devonian Botanic Garden, Devon, on moist dead wood. ALTA 8520: K. Richardson (KR48), July 25, 1988, Devonian Botanic Garden, Devon, on decaying log. ALTA 8540: K. Richardson (KR73), Oct. 1, 1988, Hondo-Slave Lake area, under bark of fallen log.

Stemonitis fusca Roth, Mag. Bot. 1: 26. 1787.

ALTA 127: L. Kennedy, Aug. 15, 1967, Pyramid Lake, [on wood]. ALTA 138: L. Kennedy (#457), Oct. 10, 1953, Edmonton, on frondose wood. ALTA 4059: M. Flewelling, July 19, 1963, Buffalo Lake, near Lacombe, on wood. ALTA 4069: R. Hnatiuk (#670285), 24 miles S of Banff on Spray River Road, Banff National Park, on fallen log. ALTA 4697: D. Yaremchuk, July 8, 1972, Devonian Botanic Garden, Devon, [on wood]. ALTA 4780: B. Wong, Aug. 4, 1971, N of Warburg, on wood. ALTA 4864: B. Wong, July 28, 1971, W of Forestry Reserve fence along riverbank, Edmonton, [on wood with moss]. ALTA 4865: J. Traquair, Aug. 12, 1972, Wabamum Lake Provincial Park, on *Populus* log. ALTA 7317: I. Tsuneda, Aug. 1976, Kinsman Park, Edmonton, on decayed wood. ALTA 8442: R. Danielson (RMD189), July 28, 1972, Calgary, North of river, on rotten *Populus* log. ALTA 8526: K. Richardson (KR56), Aug. 14, 1988, Emily Murphy Park, Edmonton, on dead log.

ALTA 8526 is placed here with some reservations. It differs from other representatives of the species because the spores lack reticulations and are only faintly spinulose, and the stalk is only 1/4 the total height rather than 1/2 the total height, as described by Martin and Alexopoulos.

Stemonitis splendens Rost., Mon. 195. 1874.

ALTA 6604: L. Gier (#938), May 19, 1974, Jasper townsite, Jasper National Park, on *Acer* log.

Stemonitopsis typhina (Wiggers) Nann.-Brem., Nederlandse Myxomyceten 203. 1974.

ALTA 4776: July 1971, Edmonton, [on wood]. ALTA 7905: L. Kennedy, Sept. 12, 1979, Edmonton, on deciduous wood. ALTA 8530: K. Richardson (KR61), Sept. 12, 1988, River valley, Edmonton, on decaying wood. ALTA 8532: K. Richardson (KR63), Sept. 12, 1988, River valley, Edmonton, in shaded area on moist decaying log. ALTA 8535: K. Richardson (KR67), Sept. 23, 1988, River valley, Edmonton, on moist decaying tree stump. *Arcyria denudata* (q.v.) also present. ALTA 8539: K. Richardson (KR72), Oct. 1, 1988, Hondo-Slave Lake area, on underside of fallen tree. DAOM 176867: G.P. White (#763), Aug. 8, 1980, Waterton National Park, on *Populus* log on *Populus* woods fringe.

Comatricha typhoides in Martin and Alexopoulos. Several of the above collections (ALTA 4060, 4063, 4776, 7905) had been deposited as *Stemonitis fusca*. *Stemonitopsis* closely resembles *Stemonitis* in its cylindric, stipitate habit, but *Stemonitopsis* lacks the surface net found in the species of *Stemonitis*.

PHYSARALES

Badhamia cf. *affinis* Rost., Mon. 143. 1874.

ALTA 4072: R. Hnatiuk, Aug. 1966, Grande Prairie, on leaves. ALTA 8482: R. Danielson (RMD1794), Sept. 14, 1975, Brown-Lowery Provincial Park, on *Populus* bark. ALTA 8483: R. Danielson (RMD1885), Sept. 7, 1975, Glenmore Park, Calgary, on rotten *Populus* log. ALTA 8498: K. Richardson (KR9), June 10, 1988, Elk Island National Park, on dead *Populus*.

Our material differs from that described by Martin and Alexopoulos in having smaller spores (9.5-11 um) than the range given for their material ((12)13-15(17) um diam.).

Badhamia cf. *cinerascens* Martin, J. Wash. Acad. Sci. 22: 88. 1932.

ALTA 8476: R. Danielson (RMD1634), July 20, 1975, Ings Creek, Longview, on litter under *Picea*.

This specimen closely resembles the description in Martin and Alexopoulos, but differs in that there is no reticulate crust on the peridium. Farr (1976) considers this a doubtful species and believes that *B. cinerascens* probably represents a phase of *B. macrocarpa*, the latter being referred to by Farr as "highly variable and nebulously defined."

Badhamia populina A. and G. Lister, Jour. Bot. 42: 129. 1904.

ALTA 146: D. States (#53), Sept. 15, 1967, North Saskatchewan River bank, Edmonton [on dead wood and pine needles].

Badhamia utricularis (Bull.) Berk., Trans. Linn. Soc. 21: 153. 1853.

ALTA 4842: R. Edwards, Oct. 1972, Hay River, on mossy wood. DAOM 176905: G.P. White (#801), Aug. 9, 1980, Belly River Trail, Waterton National Park, in mature *Populus* forest, on partially decorticated *Populus* log. DAOM 176955: G.P. White (#851), Aug. 14, 1980, along trail near Summit Lake, Waterton National Park, underside of fallen *Abies* log. DAOM 176998: G.P. White (#894), Aug. 16, 1980, in dry *Picea* woods, Crandell Lake Campground, Waterton National Park, on old *Picea* log.

Craterium leucocephalum (Pers.) Ditmar, in Sturm, Deuts. Fl. Pilze. 1: 21. 1813.

ALTA 150: E.H. Moss, Edmonton. ALTA 4098: R. Hnatiuk, July, 1966, Jasper, on wood. ALTA 4107: R. Hnatiuk, Aug. 14, 1966, Hastings Lake, on wood. ALTA 8538: K. Richardson (KR71), Oct. 1, 1988, old *Picea* forest, Hondo-Slave Lake area, on leaf litter.

Craterium minutum (Leers) Fries, Syst. Myc. 3: 151. 1829.

ALTA 151: L. Kennedy, Sept. 11, 1953, Stony Plain, on leaves. ALTA 4096: R. Hnatiuk, Aug. 1966, Grande Prairie, on plant debris.

Diderma cinereum Morgan, J. Cincinnati Soc. Nat. Hist. 16: 154. 1894.

ALTA 8447: R. Danielson (RMD472), Sept. 2, 1972, Brown-Lowery Provincial Park, 20 miles SW of Calgary, on leaves and litter of *Populus balsamifera*.

Diderma crustaceum Peck, Ann. Rep. New York State Mus. Nat. Hist. 26: 74. 1874.

ALTA 4073: R. Hnatiuk, Aug. 1966, Grande Prairie, on bark. ALTA 8076: L. Tefler, Sept. 22, 1979, Lesser Slave Lake, on moss.

Diderma globosum Pers., Neues Mag. Bot. 1: 89. 1794.

ALTA 8072: G. Jenkerson, Aug. 1975, Edmonton, on soil and moss. DAOM 58705: J.W. Eastham, Oct. 14, 1912, Gainford [on wood].

Diderma niveum (Rost.) Macbr., N. Am. Slime-Moulds. 100. 1899.

ALTA 125: R. Hnatiuk (#670098), Aug. 1966, Mount Hector, Banff, on *Menziesia ferruginea* growing with *Comatricha* cf. *rispaudii* (q.v.).

Diderma radiatum (L.) Morgan, J. Cincinnati Soc. Nat. Hist. 16: 151. 1894.

ALTA 4100: R. Hnatiuk, Aug. 1966, Jasper National Park, on wood. DAOM 58640: J.W. Eastham, Oct. 14, 1912, Gainford [on wood].

Diderma spumarioides (Fries) Fries, Syst. Myc. 3: 104. 1829.

ALTA 193: E.H. Moss, Aug. 20, 1947, Canyon Creek, on moss and wood.

Didymium squamulosum (Alb. and Schw.) Fries, Symb. Gast. 19. 1818.

ALTA 199: L. Kennedy, Sept. 26, 1952, Edmonton, on *Populus* log. ALTA 200: E.H. Moss (#7922), Aug. 22, 1947, Lesser Slave Lake, on *Alnus* twigs. ALTA 4097: L. Kennedy, Aug. 29, 1964, Devon, on twigs. ALTA 4115: L. Kennedy, Oct. 7, 1962, Thunder Lake, on *Peltigera* thallus.

Fuligo septica (L.) Wiggers, Prim. Fl. Holsat. 112. 1780.

ALTA 18: E.H. Moss, Aug. 19, 1947, Widewater, on moss. ALTA 22: E. Bozniak, Aug. 1962, Edmonton, on *Populus*. ALTA 24: E. Bozniak and J. Wheelock, Sept. 8, 1965, Hastings Lake area, on *Populus*. ALTA 153: J. States, Aug. 22, 1967, Cardinal River. ALTA 156: R. Hnatiuk, No#67/02/86?, 24 miles S of Banff on Spray River Road, Banff National Park, on pine needles. ALTA 157: D. States (#88), Sept. 9, 1967, Pembina River Provincial Park, on *Picea*. ALTA 3684: C. Strand, Sept 10, 1969, Elk Island National Park, on *Populus*. ALTA 4769: J.A. Traquair, July 30, 1972, Beauvais Provincial Park W of Pincher Creek, on *Populus* log. ALTA 4836: R. Edwards, Oct. 1972, Hay River, on herbaceous plant material. ALTA 4863: J.A. Traquair, July 1971, Wabamum Lake, on dead *Populus*. ALTA 8075: W. Wong and E.D. Allen, Aug. 31, 1972, Carson Lake. ALTA 8077: L. Abele, Aug. 18, 1982, Muir Lake, on *Populus balsamifera* trunk. ALTA 8448: R. Danielson (RMD473), Sept. 2, 1972, Brown-Lowery Provincial Park, on base of *Populus*. ALTA 8479: R. Danielson (RMD1049), Aug. 19, 1973, Fish Creek Provincial Park, Calgary, on the base of dead *Populus tremuloides*. ALTA 8508: R. Currah (KR21), July 12, 1988, Castle River area, near hillsite, on wood and pine needles. ALTA 8509: K. Richardson (KR22), July 15, 1988, Devonian Botanic Garden, Devon, on dead tree trunk. ALTA 8522: K. Richardson (KR50), Aug. 8, 1988, U of A campus, Edmonton, on wood chips. ALTA 8527: K. Richardson (KR58), Aug. 19, 1988, Edmonton river valley, on *Populus*. ALTA 8528: M. Osis and J. Gibson (KR59), Aug 19, 1988, Bretton, on decaying wood. ALTA 8549: S. Abbott (KR80), June 18, 1989, Fawcett Lake (east side), several growing on feather moss with conifer debris.

Several collections (ALTA 18, 22, 24) were originally identified as *Enteridium splendens*. Superficially, these two species resemble one another; however, *Fuligo septica* has abundant lime deposits, whereas *E. splendens* is non-calcareous.

Leocarpus fragilis (Dicks.) Rost., Mon. 132. 1874.

ALTA 161: R.F. Shaner, Aug. 15, 1946, Wabamum Lake, on wood. ALTA 165: D. States (#31), July 21, 1967, S of Nordegg on Forestry Trunk Road, on *Picea* log. ALTA 166 States (#96), Sept. 30, 1967, Nojack Campground, Nojack, on *Pinus* log. ALTA 167: D. States, Oct. 10, 1966, Elk Island National Park, Lake, north shore, on wood. ALTA 3681: P. Seymour, Aug. 30, 1969, Medicine Lake, Jasper National Park, on pine needles. ALTA 4064: Sept. 4, 1961, Whitecourt, on *Peltigera* thallus. ALTA 4106: R. Hnatiuk, Aug. 23, 1966, Cottonwood Campground, Jasper National Park, [on wood]. ALTA 4114: R. Hnatiuk, Aug 25, 1966, Wapiti Campground, Jasper National Park, [on wood]. ALTA 8445: R. Danielson (RMD409), Aug. 27, 1972, Brown-Lowery Provincial Park, on small *Picea*? twig. ALTA 8512: K. Richardson (KR27), July 22, 1988, Devonian Botanic Garden, Devon, on *Picea* needles. ALTA 8543: K. Richardson (KR76), Oct. 1, 1988, Hondo-Slave Lake area, on a twig.

Mucilago crustacea Wiggers, Prim. Fl. Holsat. 112. 1780.

ALTA 202: E. Bozniak, Aug. 1962, Edmonton, on wood. ALTA 203: E. Bozniak and J. Wheelock, Sept. 9, 1965, Hastings Lake area, on leaves. ALTA 204: L. Kennedy, Sept. 26, 1968, Edmonton, [on twig]. ALTA 205: Edmonton, bank of North Saskatchewan River, [on plant matter]. ALTA 206: E.H. Moss, Aug. 20, 1947, Canyon Creek, on *Viburnum* and *Fragaria* stems. ALTA 4312: 1970, Edmonton, on *Rosa* stems. ALTA 4866: G. McPherson, Aug. 31, 1971, Hotchkiss River, on leaf litter and moss. ALTA 7483: I. Tsuneda, Sept. 1975, Edmonton river valley, on *Sorbus americana* petiole on ground. ALTA 8450: R. Danielson (RMD504), Sept. 4, 1972, Glenmore Park, Calgary, on grass blades. ALTA 8519: K. Richardson (KR43), July 26, 1988, Wates-Gibson Hut, Tonquin Valley, Jasper National Park, on *Rubus pedatus* stem. ALTA 8541: K. Richardson (KR74), Hondo-Slave Lake area, on moss at base of living *Populus tremuloides*. ALTA 8546: B. Hocking, Aug. 29, 1971, Wabamum Lake, [on twig]. DAOM 58939: J.N. Wallace, Aug. 8, 1923, Calgary, [on branch and leaf]. DAOM 173184: ex Herb. Gordon, June 25, 1926, river bank, Edmonton.

Physarum cf. *albescens* Ellis ex Macbr., N. Am. Slime-Moulds. ed. 2. 86. 1922.

DAOM 147216: C.D. Bird (#16258), June 22, 1966, Livingstone Range, Oldman River Watershed, E side of S peak of Hailstone Butte, NW23-14-4-W5, elevation 7400 feet, on grass and *Saxifraga bronchialis*.

DAOM 147216 closely resembles *P. albescens* in all characteristics except spore size, which is smaller (10.5-12.5 um) than the measurements given by Martin and Alexopoulos (12-15 um).

Physarum bethelii Macbr., ex Lister, Mycet. ed. 2. 57. 1911.

ALTA 4082: R. Hnatiuk, Aug. 22, 1966, Honeymoon Lake, Jasper National Park, on bark.

Physarum bivalve Pers., Ann. Bot. Usteri. 15: 5. 1795.

ALTA 169: L. Kennedy, Aug. 11, 1953, Stony Plain, on dead leaves [and *Alnus* cone]. ALTA 208: E. Bozniak, Aug. 1962, Edmonton, on dead leaves. ALTA 4856: J. Traquair (T135), Aug. 4, 1971, Drayton Valley, on leaves.

Martin and Alexopoulos described the spores of this species as minutely and uniformly spinulose. ALTA 208 differs slightly in having markedly spinulose spores.

Physarum cinereum (Batsch) Pers., Neues Mag. Bot. 1: 89. 1794.

ALTA 170: L. Kennedy, July 15, 1958, Edmonton, on grass. ALTA 4088: P. Seymour, Oct. 8, 1964, Edmonton, on *Populus* log. DAOM 4544: G.B. Sanford, 1936, Alberta: [on old fungus fruiting body?]. DAOM 159960: J.G.M. Davidson, July 14, 1976, Beaverlodge Research Station, on *Festuca*.

Physarum compressum Alb. and Schw., Consp. Fung. 97. 1805.

ALTA 171: J. States, Sept. 6, 1968, Conjuring Creek, [on wood]. DAOM 58506: J.W. Eastham, Oct. 14, 1912, Gainford, [on wood]. DAOM 58509: J.W. Eastham, Oct. 14, 1912, Gainford, [on wood].

The spore size (9-10.5 um) is smaller than that given by Martin and Alexopoulos (10-12.5 um). ALTA 171 has unbranched plasmodiocarps interspersed with sessile sporangia.

Physarum contextum (Pers.) Pers., Syn. Fung. 168. 1801.

ALTA 173: D. States (10), Sept. 25, 1966, Nojack Picnic Area, Nojack. ALTA 4092 E. Bozniak, Aug. 1962, Edmonton, on *Betula* bark.

Physarum leucopus Link, Ges. Nat. Freunde Berlin. Mag. 3: 27. 1809.

ALTA 4770: J.A. Traquair, July 30, 1972, Beauvais Provincial Park, W of Pincher Creek, on *Populus* log. ALTA 4861: J.A. Traquair, Aug. 16, 1972, Devonian Botanic Garden, Devon, on *Populus* log. ALTA 8444: R. Danielson (RMD408), Aug. 27, 1972, Brown-Lowery Provincial Park, on *Picea* (?) bark. ALTA 8446: R. Danielson (RMD471), Aug. 2, 1972, Brown-Lowery Provincial Park, on rotten *Populus tremuloides* log. ALTA 8451: R. Danielson (RMD505), Sept. 4, 1972, Glenmore Park, Calgary, on rotten *Populus* log. ALTA 8454: R. Danielson (RMD701), May 2, 1973, Beaverdam Flats, Calgary, on underside of *Populus* log. ALTA 8461: R. Danielson (RMD1048), Aug. 19, 1973, Fish Creek Provincial Park, (CFNS area #37), Calgary, on the moss *Pylaisiella polyantha*. ALTA 8481: R. Danielson (RMD1775), Sept. 9, 1975, Yamnuska, Seebe, on old *Populus* bark. ALTA 8510: K. Richardson (KR23), July 18, 1988, Red Deer River Campsite, near Sundre, on rotting log. ALTA 8515: K. Richardson (KR35), July 26, 1988, Wates-Gibson Hut, Tonquin Valley, Jasper National Park, underneath bark of a fallen log. ALTA 8537: K. Richardson (KR70), Sept. 24, 1988, Wabasso Campground, Jasper National Park, in *Pinus contorta* forest, on decaying wood.

Physarum luteolum Peck, Ann. Rep. New York State Mus. Nat. Hist. 30: 50. 1878.

ALTA 176: L. Kennedy, June 29, 1963, Devon, on dead *Populus* leaves.

Physarum notabile Macbr., N. Am. Slime-Moulds. ed. 2. 80. 1922.

ALTA 4841: R. Edwards, Oct. 1972, Hay River area, [on wood]. ALTA 8544: K. Richardson (KR77), Oct. 1, 1988, Bullet Lake *Larix* bog, Hondo-Slave Lake area, inside a cavity in a moist, decaying log.

Physarum oblatum Macbr., Bull. Nat. Hist. Univ. Iowa Iowa 2: 384. 1893.

ALTA 4081: R. Hnatiuk, Aug. 14, 1966, Hastings Lake, [on wood]. ALTA 4108: R. Hnatiuk, Aug. 23, 1966, Cottonwood Campground, Jasper National Park, [on wood]. ALTA 8484: R. Danielson (RMD1891), April 6, 1976, Brown-Lowery Provincial Park, on *Populus tremuloides* bark. DAOM 176881: G.P. White (#777), Aug. 8, 1980, Waterton National Park, on rotting *Populus* branch. DAOM 177038: G.P. White (#934), Aug. 20, 1980, Belly River, Waterton National Park, on rotting *Populus* log in *Populus* woods.

Physarum pusillum (Berk. and Curt.) G. Lister, Mycet. ed. 2. 64. 1911.

ALTA 4117: R. Hnatiuk, Aug. 25, 1966, Wapiti Campground, Jasper National Park, [on wood].

The spores of ALTA 4117 are slightly smaller (8.5-10 um) than those described by Martin and Alexopoulos ((9)10-12 um).

Physarum rubiginosum Fries, Symb. Gast. 21. 1817.

ALTA 184: A. Stewart, Sept. 11, 1963, Whitecourt, area C, under conifer needles [poor specimen]. ALTA 8458: R. Danielson (RMD997), Aug. 9, 1973, Fish Creek Provincial Park, Calgary, on moss (*Distichum capillaceum*) growing on rotten stump in *Picea glauca* stand (CFNS #41).

Physarum serpula Morgan, J. Cincinnati Soc. Nat. Hist. 19: 29. 1896.

ALTA 185: L. Kennedy (#408), Sept. 11, 1953, Stony Plain, on wood.

Physarum sp.

ALTA 8443: R. Danielson (RMD407), Aug. 27, 1972, Brown-Lowery Provincial Park, 20 miles SW of Calgary, on *Picea glauca* litter, living grass blades and moss.

This specimen is distinctive but unassignable. However, it somewhat resembles the description of *P. digitatum* given by Martin and Alexopoulos.

Physarum tenerum Rex, Proc. Acad. Nat. Sci. Philadelphia. 42: 192. 1890.

DAOM 176852a: G.P. White (#748), Aug. 5, 1980, Cameron Lake Road, Waterton National Park, on rotting wood in *Pinus* woods. DAOM 198858: G.P. White (#881), Aug. 15, 1980, Waterton National Park, on fallen conifer in *Pinus-Abies* woods.

Physarum tessellatum Martin and Farr, Lloydia 22: 300. 1960.

ALTA 4109: R. Hnatiuk, Aug. 1966, Grande Prairie, on dead leaves.

Physarum cf. *viride* (Bull.) Pers., Ann. Bot. Usteri. 15: 6. 1795.

DAOM 176954: G.P. White (#850), Aug. 14, 1980, near Summit Lake, Waterton National Park, on decorticated *Abies*.

The sporangia of this specimen are slightly larger (0.8 mm) than the size (0.3-0.6 mm) noted in Martin and Alexopoulos. They also described the peridium as "splitting into irregular fragments above and floriform lobes below," but this unusual characteristic was not evident in DAOM 176954. The spores of this specimen are also smaller (7-9 um) than those described by Martin and Alexopoulos (10-12 um).

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ACERVICLYPEATUS, A NEW GENUS FOR THE ANAMORPH OF OPHIODOTHELLA VACCINII

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ABSTRACT

The anamorph of *Ophiodothella vaccinii* produces a modified acervulus that is covered by a black clypeus perforated by a central pore. The pore is formed by a vertical column of hyphae inside the acervulus. Because of its unusual morphology, this fungus is placed in the new genus *Acerviclypeatus*.

Keywords: Coelomycetes, Deuteromycotina, Melanconiales, *Ophiodothella*, Phialostromatineae, *Vaccinium*, flyspeck leafspot.

INTRODUCTION

Ophiodothella vaccinii Boyd is the cause of a common leafspot disease (flyspeck leafspot, black-speckled leaf spot) of *Vaccinium* spp. in the southern United States (Farr et al., 1989). The disease first appears in early summer as lesions that bear the anamorph of the fungus. Boyd (1934) described the anamorph as an acervulus with scolecosporous conidia, however, preliminary observations of conidioma development indicate that it differs in several respects from other acervulate coelomycetes. Consequently, detailed studies of the fungal structure were undertaken, some results of which are reported below.

MATERIALS AND METHODS

Studies were conducted on living material growing on leaves of *Vaccinium arboreum* Marsh. and supplemented by sections. Material to be sectioned was fixed in formalinpropionic acid-alcohol (FPA), then embedded in paraffin, following the procedures of Hanlin and Tortolero (1989). Measurements of 25 conidiophores and conidia were made on fresh material mounted in water, whereas measurements of 10 acervuli were made on sectioned material. Macrophotographs were taken with a Nikon F2 camera equipped with a micro lens. Photomicrographs were taken with a Nikon HFX camera on either a Nikon Optiphot or a Nikon SMZ-10 stereo microscope. All photographs were taken on Kodak Technical Pan 2415 film.

OBSERVATIONS

Young leafspots first appear as small, circular, chlorotic areas on the leaf. As these lesions enlarge they become reddish-orange in color, usually with a darker border. Soon after the lesions form, small, circular, raised areas become visible in them; these are the incipient conidiomata. Soon after young conidiomata can be distinguished, a small pore is formed in the center. Sections through developing conidiomata show that the pore is formed by a vertical column of hyphae ("pore-puncher") that grows up from the base of the conidioma and perforates the overlying epidermis (Hanlin, 1989). As the conidioma matures, the epidermal cells remain intact and become filled with pigmented hyphae, forming a clypeus. Large numbers of scolecosporous conidia are produced on a basal layer of conidiophores; at maturity they are liberated through the pore. Although the conidioma is ontogenetically an acervulus, it differs from other acervuli in the presence of a distinct clypeus covering the conidioma. The clypeus consists of the persistent epidermal cells filled with pigmented hyphae. Also unique is the presence of a vertical mass of hyphal cells which pushes through the epidermis during the early stages of development to form the central pore. Because of the unusual structure and ontogeny of this fungus, a new genus is proposed to accomodate it.

Acerviclypeatus **Hanlin gen. nov.**

Acervuli in maculis in foliis vivis, subepidermales, circulares, clypeis convexis nigeris tectis; clypeus cum porus centralis, columna verticali hyphae formatus. Conidiophora aggregata in strata basalia, ramosa, cum aliquot cellulae conidiogenae; cellulae conidiogenae graciles, angustatae apices versus. Conidia unicellularia, hyalina, filiformia, per poros extrusos.

Teleomorphosis: *Ophiodothella.*

In foliis vivis *Vaccinii.*

Ad classem Coelomycetes, ordinem Melanconiales pertinet.

Acervuli formed in leafspot, subepidermal, circular, surface convex, covered by a black clypeus; clypeus with central pore formed by a vertical column of hyphae. Conidiophores crowded in a basal layer, branched; conidiogenous cells slender, tapering toward the apex. Conidia one-celled, hyaline, filiform, extruded through pore.

Teleomorph: *Ophiodothella.*

In living leaves of *Vaccinium.*

Belonging to class Coelomycetes, order Melanconiales.

Etymology: *Acerviclypeatus* = Latin, Acervus (heap) + clypeatus (shield-shaped, i.e., referring to the convex covering).

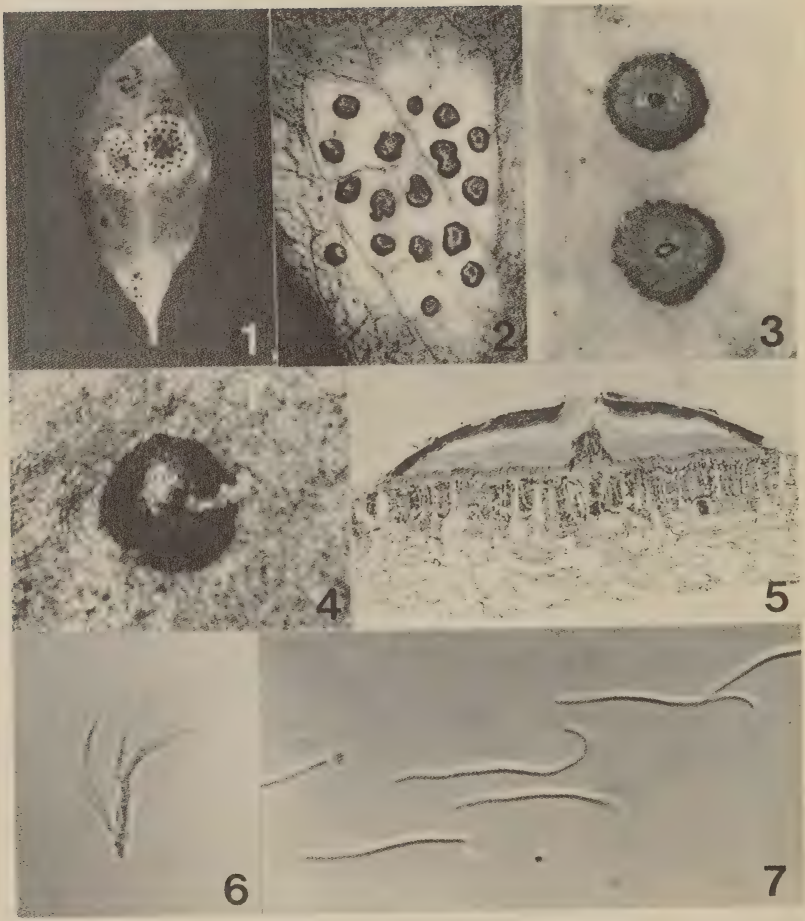
Acerviclypeatus poriformans **Hanlin sp. nov.**

Acervuli in maculis in foliis vivis, subepidermales, circulares, 536 µm lata X 89 µm alta, clypeis convexis nigeris tectis; clypeus cum porus centralis, columna verticali hyphae formatus. Conidiophora aggregata in strata basalia, ramosa, cum aliquot cellulae conidiogenae; cellulae conidiogenae graciles, angustatae apices versus, 19 µm longa X 2 µm lata. Conidia unicellularia, hyalina, filiformia, 24 X 1 µm, saepe curvata apices una versus, per poros extrusos.

Teleomorphosis: *Ophiodothella vaccinii* Boyd.

In foliis vivis *Vaccinii arborei*, Madison County, Georgia, USA., R. T. Hanlin (#903), September 10, 1989. Holotypus: In GAM (#12745).

Acervuli formed in leafspot in living leaves (Fig. 1-2), subepidermal, circular (Fig. 3), 536 µm wide X 89 µm high, surface convex, covered by a black clypeus with a central pore; pore formed by a vertical column of hyphae (Fig. 5). Conidiophores crowded in a basal layer, branched (Fig. 6);



Figs. 1-7. *Acerviclypeatus poriformans*. Fig. 1. Lesions on leaf of *Vaccinium arboreum*. X1. Fig. 2. Close-up of lesion with conidiomata. X16. Fig. 3. Two conidiomata with pore in clypeus. X69. Fig. 4. Close-up of mature conidioma with cirrhus of conidia protruding from pore. X57. Fig. 5. Section through leaf bearing subepidermal conidioma with pore, pore-puncher, conidia, and clypeus. X114. Fig. 6. Branched conidiophore. X1286. Fig. 7. Conidia. X1389.

conidiogenous cells slender, 19 μm long X 2 μm wide, tapering toward apex. Conidia one-celled, hyaline, filiform, 24 X 1 μm, often curved at one end (Fig. 7), extruded through pore (Fig. 4).

Teleomorph: *Ophiodothella vaccinii* Boyd.

On living leaves of *Vaccinium arboreum* Marsh., Madison County, Georgia, USA., R. T. Hanlin (#903), September 10, 1989. Holotype: In GAM (#12745).

Etymology: *poriformans* = Latin, porus (pore) + formans (forming).

DISCUSSION

The most striking feature of this fungus is the formation of a pore by a vertical mass of hyphae that grows up and perforates the clypeus. Boyd (1934) observed that the basal plectenchyma of the acervulus became umbonate in the center of some acervuli, but she did not comment further on it. This unusual structure is not known to occur in other coelomycetes. In *Discosporina* Höhnel there is a central pulvinate mass of fungal tissue that may function in breaking the overlying periderm of the host (branches of *Carpinus*) (Sutton, 1980), but this structure is quite different from that found in *A. poriformans*. The conidia and teleomorphs of the two fungi also differ.

Acerviclypeatus is clearly coelomycetous in its development and would be placed in class Coelomycetes, order Melanconiales (Sutton, 1973) in traditional classification schemes. Conidiogenesis appears to be phialidic, but this could not be determined precisely due to the small size of the apex of the conidiogeneous cell. If this is so, this fungus would fall under the suborder Phialostromatineae of Sutton (1980). Transmission electron microscopy would be required to resolve this question.

On cursory examination, *Acerviclypeatus* could be mistaken for *Septoria* because of its hyaline, scolecosporous conidia and perforate conidioma, but *Septoria* species differ in forming a distinct pycnidium.

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TAXONOMIC AND NOMENCLATURAL NOTES ON LACCARIA B. & BR. III. LACCARIA AMETHYSTINA AND L. IMPOLITA

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Additional information concerning the nomenclature and synonymy of some names in the genus *Laccaria* has been obtained since our previous publications (Mueller & Vellinga, 1986; Vellinga & Mueller, 1987). Two nomenclatural problems are treated here: 1) the correct name for the violet colored *Laccaria* species found commonly in Europe and eastern North America, and 2) a legitimate name for the bisporic taxon proposed by Ballero & Contu (1989).

Laccaria amethystina (Huds.→[1]) Cooke--Fig. 1

≡ *Agaricus amethystinus* Huds., Fl. angl. 2: 612, 1778; *non Agaricus amethystinus* Scop., Fl. carn. 2: 437, 1772 (=*Cortinarius* spec.); *nec Agaricus amethystinus* Schaeff., Fung. Bavar. Palat. nasc. 4: 24, 1774 (=*Cortinarius traganus*).
= *Laccaria amethystina* (Huds.→) Cooke, Grevillea 12: 70, 1884.
= *Collybia amethystina* (Huds.→Cooke) Quél., Fl. mycol. France: 237, 1888.
= *Clitocybe amethystina* (Huds.→Cooke) Peck, Annual Rep. New York State Bot. 50: 128, 1897.

≡ *Agaricus amethysteus* Bull., Herb. France: Pl. 198, 1784 (=*A. laccatus* Schaeff., Fung. Bavar. Palat. nasc. 4:8, 1774).
= *Omphalia amethystea* (Bull.→) S. F. Gray, Nat. arr. Brit pl. 1: 614, 1821.
= *Agaricus laccatus* var. *amethysteus* (Bull.) B. & Br., J. Linn. Soc. Bot. 11: 518, 1871.

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[1] For the use of the arrow see Mueller & Vellinga, 1986: 27.

= *Russuliopsis laccata* var. *amethystea* (Bull.) J. Schroet. in Cohn, Krypt.-Fl. Schlesien 3(1): 623, 1889 (erroneously written '*amethystina*').
= *Laccaria amethystea* (Bull.) Murrill, N. Amer. Fl. 10: 1, 1914.

≡ *Laccaria calospora* Singer, Beih. Sydowia 7: 7, 1973.

Neotype *nov.*: England, Devon, Dartmoor, Two Bridges, Whistmans Wood, 6.IX.1971, *D. N. Pegler s.n.* (as *L. amethystea*) (K!).

A reexamination of Bulliard's original plate and description of *Agaricus amethysteus* (Bulliard, 1784) indicates that he viewed this name as a synonym of *A. laccatus* Schaeff. (Schaeffer, 1774) and thus is a superfluous name. It is unfortunate that this well known name cannot be used because it is clear that Bulliard only referred to a part of Schaeffer's plate (1762: pl. 13). Persoon (1800: 6, 7) discerned three species in this plate, *Agaricus amethysteus*, *A. farinaceus* Huds. and *A. rosellus* Batsch. Mueller and Vellinga (1986) reported that *A. amethystinus* Huds. (Hudson, 1778) was a homonym of *A. amethystinus* Scop. (= *Cortinarius* sp.) and could not be used. The first legitimate name published for the amethyst colored *Laccaria* was *L. amethystina* (Huds.→) Cooke (Cooke, 1884).

The collection designated as neotype of *L. amethystina* was selected from material requested from several herbaria. No original material or other collections seen by Hudson were located. The chosen collection fits Hudson's protologue and was collected in England. The neotype has the following micromorphological characteristics.

Basidiospores (excluding ornamentation) (n=30) 8.5-10.0 x 8.0-10.0 μm, $\bar{x}$ = 9.2 ± 0.37 x 9.1 ± 0.41 μm, Q = 1.0-1.06, $\bar{Q}$ = 1.01 ± 0.02, globose, occasionally subglobose, echinulate; spines up to 1.5-2.5 μm high, crowded; hilar appendage 1.4 μm long, prominent, truncate; contents occasionally uniguttulate; wall inamyloid and acyanophilous. Basidia 38-55 x 11-15.5 μm, clavate, elongate, hyaline, tetrasporic. Pleurocystidia absent. Cheilocystidia 40-70 x 5.5-11.5 μm, filamentous to subclavate, often somewhat strangulate, abundant, thin-walled, hyaline. Pileipellis a cutis of radially arranged cylindrical hyphae 4-20 μm wide with numerous scattered more or less perpendicular large individual hyphae or small fascicles of 2-3 large hyphae; terminal elements 40-58 x 9-16 μm, filamentous to clavate, some strangulate, hyaline to light vinaceous; walls up to 0.5 μm thick. Clamp connections abundant.

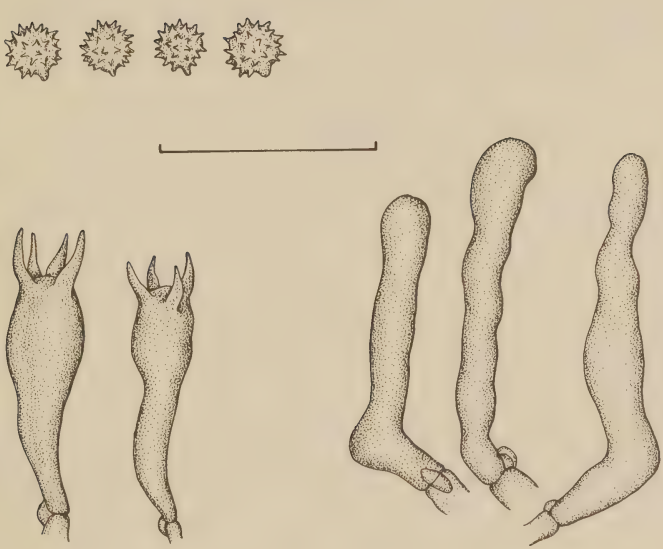

Fig 1. *Laccaria amethystina* (Neotype, *D. N. Pegler s.n.*, 6.IX.1971). -- Typical globose echinulate basidiospores. --Basidia. -- Cheilocystidia. Scale line = 40 µm.

LACCARIA IMPOLITA Vellinga & G. M. Mueller *nom. nov.*

≡ *Laccaria singeri* Ballero & Contu, Candollea 44: 122, 1989; *non Laccaria singeri* M. V. Locquin & B. M. Sarwal [as 'singerii'], in Sarwal & Locquin *Comptes rendus du 108ᵉ Congrès national des Sociétés savantes, Grenoble 1983 Section des Sciences* **1**; Sciences de la Terre **2**: 195, 1983.

Laccaria singeri Ballero & Contu (1989) is a homonym of *L. singeri* Locquin & Sarwal (1983) and cannot be used. The name *L. impolita* is proposed as a legitimate name for the taxon described by Ballero & Contu.

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Nils Lundqvist (S) and Svengunnar Ryman (UPS) are acknowledged for suggesting the reexamination of Bulliard's publication. Thomas W. Kuyper's nomenclatural advice is gratefully noted. We are grateful to Roy E. Halling for reviewing this paper. Dr. D. N. Pegler is thanked for the loan of specimens from K.

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Schaeffer, J. C. 1774. *Fungorum qui in Bavaria et Palatinatu nascuntur icones* IV. Ratisbonae [Regensburg].

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ADDITION TO SUBULISPORA FROM MALAYSIA

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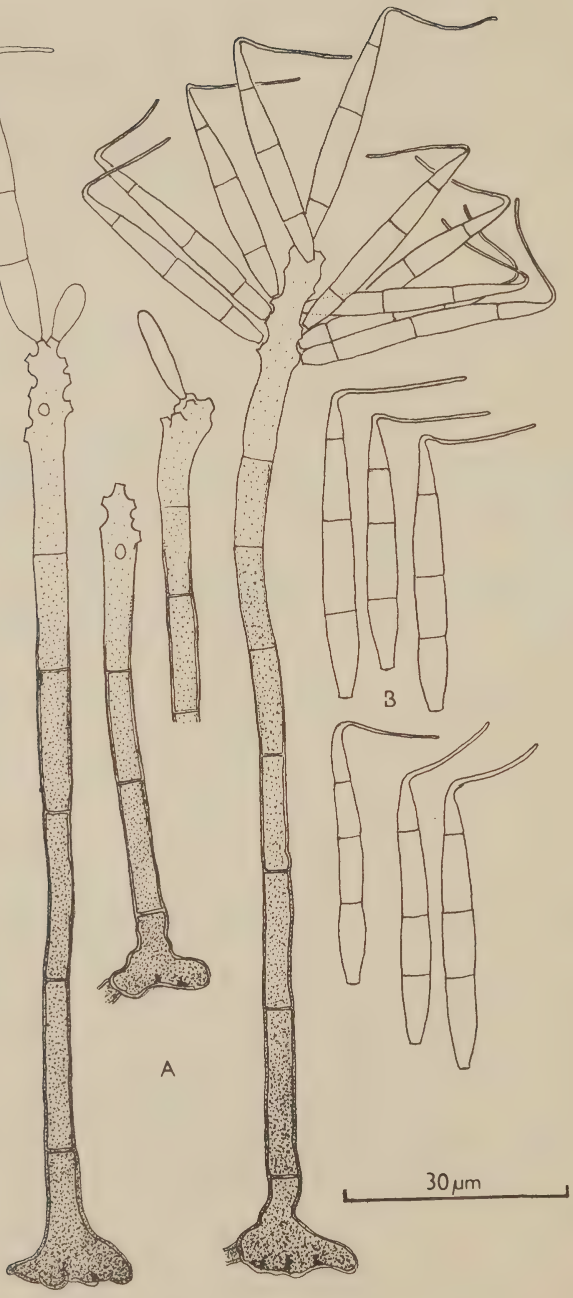
Subulispora malaysiana sp. nov., collected from decaying leaves under water from Malaysia is described and illustrated.

Nawawi & Kuthubutheen (1987) recorded the occurrence of **Subulispora procurvata** Tubaki, the type species of the genus from Malaysia and described a new species **S. longirostrata** Nawawi & Kuthubutheen with similar characteristics to the type species but differs only in conidial size. This paper describes another fungus which is considered to be congeneric with **Subulispora.** It was isolated from submerged decaying leaves in a fresh water stream.

Subulispora malaysiana sp. nov. Figs. 1 - 2

Coloniae effusae, pallide brunneae, inconspicuae. Mycelium partim superficiale, partim in substrato immersum, ex hyphis laevibus, ramosis, septatis, pallide brunneis 1.5 — 3 µm latis compositum. Conidiophora macronematosa, mononematosa, solitaria vel gregaria, erecta, simplicia, recta vel leviter flexuosa, 3 — 8 septata, 68 — 186 µm longa x 3.5 — 5.5 µm lata, laevia, brunnea, apicem versus pallidiora, cylindrica, ad fundamentum inflata, 15 — 19 µm lata. Cellulae conidiogenae in conidiophoris incorporatae, terminales, polyblastica, sympodiales, hyalina vel subhyalina, parietibus crassis, 12 — 29 µm, 4 — 5 µm non-septatis, cum 5 — 12 cicatricibus non incrassatis, complanatis, prominentibus 3 — 4 µm diam. Conidia acrognea, sicca, solitaria, diem acropleurogena, 3 (-4) — euseptata, 34 — 42 µm longa (appendicula exclusa) x 4 — 5 µm lata, laevia, hyalina vel subhyalina, cylindro-obclavata, basi anguste truncata, apice longe attenuata flexa, ad 13 — 18 µm longa, non vel leviter constricta ad septum. Conidiorum secessio schizolytica.


A
B
30 µm

Ex foliis angiospermis putrescentibus influmine immersi, Lipur Lintang Forest Reserve, Pahang, Malaysia, 9 April, 1987, A. Nawawi, IMI 315803 holotypus.

Colonies effuse, pale brown, inconspicuous. **Mycelium** partly superficial, partly immersed in the substratum, composed of smooth, branched, septate, pale brown, 1.5 — 3 µm wide hyphae. **Conidiophores** macronematous, mononematous, solitary to gregarious, erect, simple, straight to slightly flexuous, 3 — 8 septate, 68 — 186 µm long, 3.5 — 5.5 µm wide, smooth, brown, paler towards the apex, occasionally with 1 — 2 percurrent regenerative proliferations (not associated with conidiogenesis), base expanded to 15 — 19 µm wide and radially lobed. **Conidiogenous cells** integrated, terminal, polyblastic, sympodial, hyaline to subhyaline, thin-walled, 12 — 29 µm long, 4 — 5 wide with 5 — 12 protuberant, unthickened truncate scars 3 — 4 µm diam. **Conidia** acrogenous, dry, solitary, later acropleurogenous, smooth, hyaline to subhyaline, cylindro-obclavate, 3 (-4) — euseptate, 34 — 42 µm long (excluding the appendage), 4 — 5 µm wide, non or slightly constricted at the septa, with a conico-truncate, slightly thickened base, 3 — 4 µm wide, tapering gradually upwards to form a thin, abruptly bent, curved, non-septate appendage, 13 — 18 µm long, 0.5 µm wide, disposed at 45 — 130° to the axis of the conidium. Conidial secession schizolytic.

Conidia tend to remain in situ after maturation. They germinate readily on agar media by producing germ-tubes from the cells of the main body and anywhere along the appendage. On CMA the colonies are chocolate to reddish brown, zonate, with a sparse, wooly aerial mycelium, reverse chocolate brown, attaining a diam. of 35 mm in 22 days at 25 — 28°C. No sporulation occurred on dry agar and only sparingly on strips of colonies immersed in water. Conidia were formed mostly on the exposed areas of the colony.

The generic classification of this fungus is somewhat difficult. It has been considered for inclusion in such genera as **Dactylaria** Sacc., **Pyriculariopsis** Ellis and **Solosympodiella** Matsushima. It is with some hesitation that it is referred to **Subulispora.** Its conidia are not unlike those of **S. procurvata** in

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Fig. 1. **Subulispora malaysiana.** A, Conidiophores bearing developing and mature conidia; B, typical conidia.

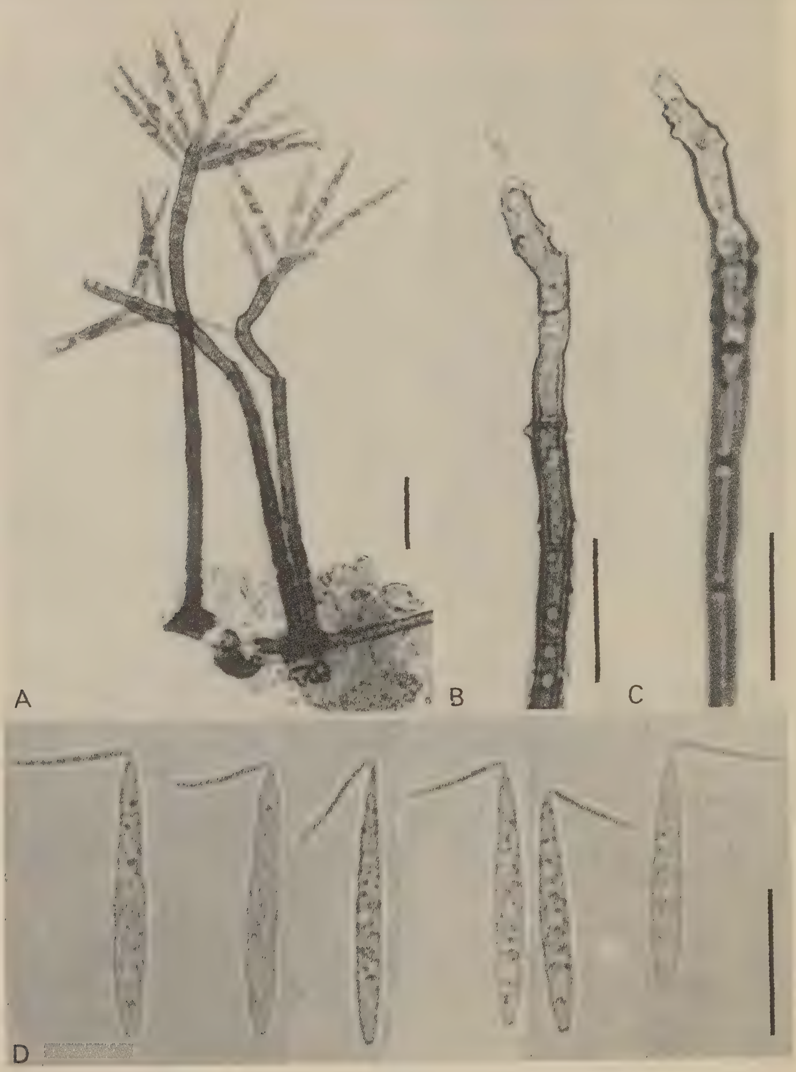

Fig. 2. **Subulispora malaysiana.** A, Conidiophores with attached conidia; B - C, part of conidiophores showing sporogenous regions; D, mature conidia. All bars = 20 μm.

being hyaline, 3-septate and the possession of a long, thin curved apical appendage. Further the dark mononematous conidiophores with expanded and lobed bases, the lighter coloured, non-septate conidiogenous zone that lengthens through sympodial proliferations, the arrangements of the conidia along the conidiogenous apex, the conidia remaining in situ after maturity and their eventual secession schizolytically resemble members of **Subulispora.** It departs slightly from **Subulispora** because the conidia are borne on raised rather than flat scars and the base of the conidia, although truncate, is narrower than the main body.

S. argentina Arambarri & Mengascini described by Arambarri, Cabello & Mengascini (1987) from Argentina on an unspecified substrate appears to be congeneric but not conspecific with **S. malaysiana.** Both produce conidia with rather similar morphology borne on raised, truncate scars. **S. argentina,** however, has shorter conidia (total length 25 — 35 µm) and their appendages are not sharply bent.

We are grateful to Prof. E.B.G. Jones, Portsmouth Polytechnic, for reviewing the manuscript.

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MYCOTAXON

Vol. XXXVII, pp. 395-400 April-June 1990

OBELIOSPORA, A NEW GENUS OF SETOSE, PHIALOSPOROUS HYPHOMYCETES WITH APPENDAGED CONIDIA

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A dematiaceous hyphomycete colonizing submerged decaying wood in a freshwater stream is described and illustrated as **Obeliospora basispira** gen. et sp. nov. It produces subglobose, hyaline appendaged conidia formed singly within a deep collarette at the apex of doliiform phialides. It is compared with known phialosporous, dematiaceous genera with hyaline appendaged conidia.

Obeliospora gen. nov.

Coloniae effusae, brunneae. Mycelium immersum vel superficiale, ex hyphis ramosis, septatis, pallide brunneis, laevibus compositum. Setae simplices, steriles, erectae, rectae vel curvatae, septatae, crassitunicatae, attenuatae, ad basim inflatae. Conidiophora macronematosa, mononematosa, solitaria vel aggregata, simplicia, recta vel flexuosa, laevia, septata, pallide brunnea. Cellulae conidiogenae in conidiophoris incorporatae, terminales, monophialidicae; colla conspicue, cupulatae, successione conidiorum planum eundem producentes proliferatione enteroblasticae. Conidia holoblastica, solitaria, sicca, hyalina, globosa vel subglobosa cum setulae coronata simul gemmantia.

Specia typica: O. basispira sp. nov.

Colonies effuse, brown. **Mycelium** immersed or superficial formed of branched, septate, pale brown, smooth hyphae. **Setae** simple, sterile, erect, straight to curve, septate, thick-walled, attenuated, with inflated base. **Conidiophores** macronematous, mononematous, solitary or grouped, simple, straight or flexuous, smooth, septate, pale brown. **Conidiogenous cells** incorporated in the conidiophores, discrete, terminal, monophialidic; collarette conspicuously flared and cup-shaped, proliferating enteroblastically to produce a succession of conidia at the same

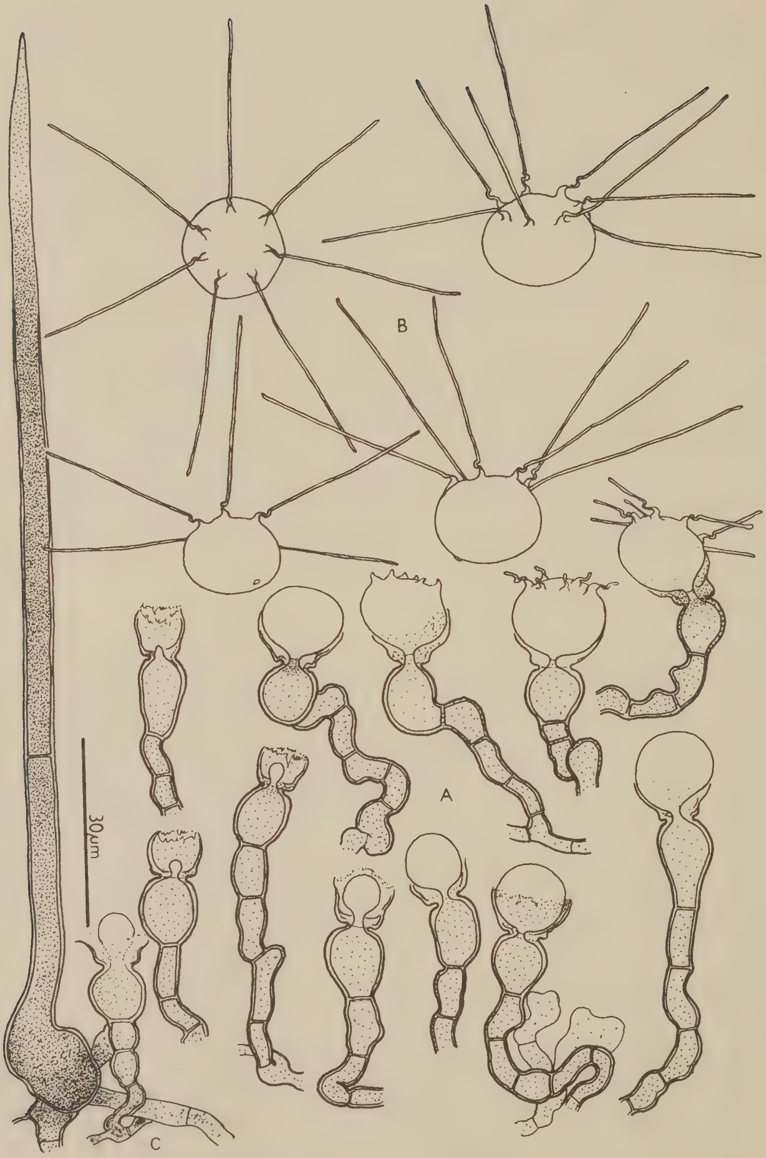


Fig. 1. **Obeliospora basispira.** A, conidiophores with conidia at various stages of formation from twigs; B, mature conidia; C, a typical seta.

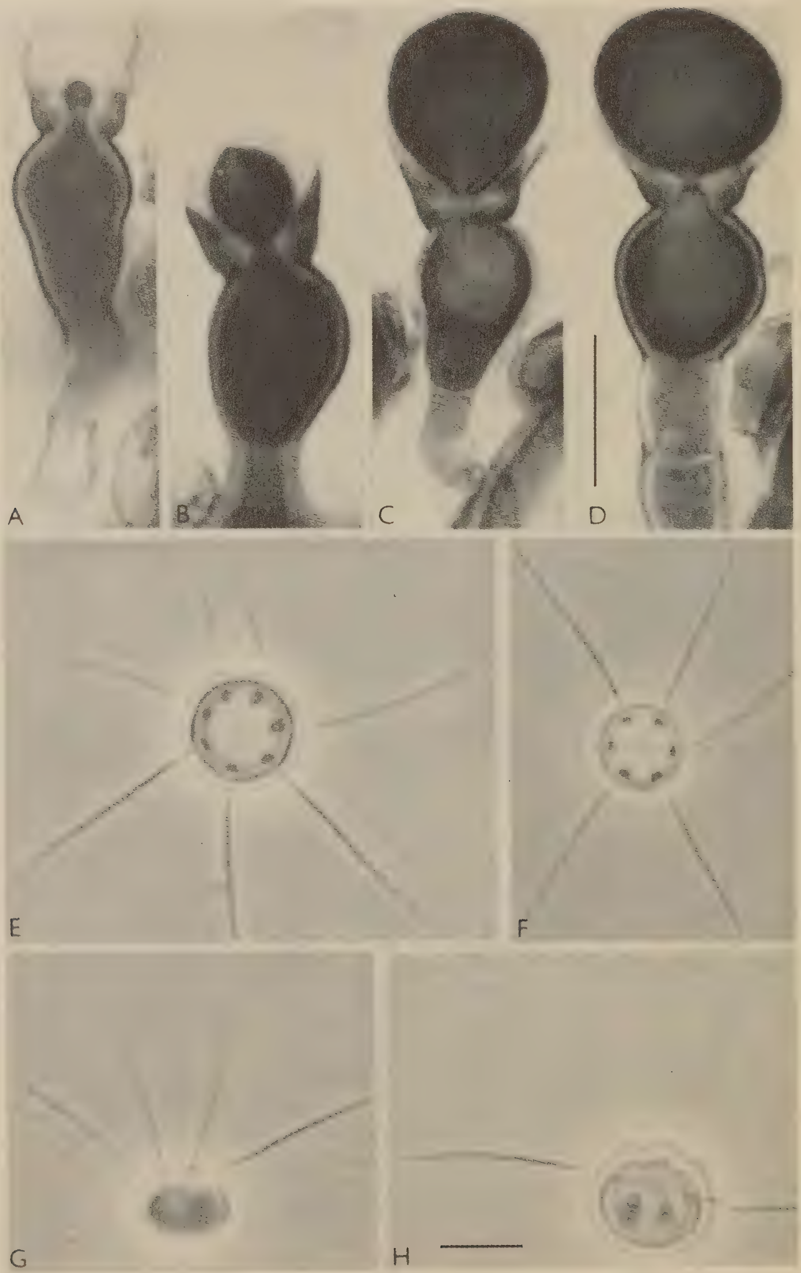
level. Conidia holoblastic, solitary, dry, hyaline, globose to subglobose furnished with several appendages formed simultaneously about the crown.

Obeliospora basispira sp. nov. Figs. 1 - 2

Coloniae effusae, pallide brunneae vel brunneae. Mycelium immersum vel superficiale, ex hyphis ramosis, septatis, pallide brunneis, laevibus 2 - 3 µm crassis compositum, ad bases setarum et conidiophorum aggregatum. Setae steriles, simplices, erectae, rectae vel leniter curvatae, atrobrunneae, crassitunicatae, laeves, 1 — 2 septatae, apicem acutum versus attenuatae, usque ad 190 µm longae x 4 — 5 µm crassae, ad basim inflatae, 10 — 18 µm crassae. Conidiophora macronematosa, mononematosa, solitaria vel 2 - 4 aggregata, ex hypharum aggregatum oriunda, simplicia, raro ramosa, flexuosa, pallide brunnea, laevia, 3 - 5 septata, 20 - 38 µm longa, basi 2.5 - 3 µm crassa. Cellulae conidiogenae in conidiophoris integratae, terminales, monophialidicae, doliiformia, 8 - 13 µm longae x 8 - 10 µm crassae; colla conspicue cupulata, 5 - 10 µm diam x 7 - 14 µm alta; seccession conidiorum planum eundem producentes proliferatione enteroblastica. Conidia acrogena, solitaria, sicca, subglobosa vel napiformia, laevia, hyalina, parietibus tenuibus, 15 - 19 µm diam , 13 - 15 µm alta, cum 4 - 8 setulae coronata simul gemmantia, 25 - 46 µm x 0.3 - 0.5 µm. Conidiorum secessio schizolytica.

In ramunculus emortuos ignotes, Waterfall, Kota Tinggi, Johore, Malaysia, 10 Oct. 1988, A.J. Kuthubutheen, IMI 334130 holotypus.

Colonies effuse, light brown to brown. **Mycelium** immersed or superficial, composed of light brown, branched smooth, septate hyphae 2 - 3 µm wide, loosely aggregated at the base of setae and conidiophores. **Setae** arising singly at regular intervals, sterile, simple, erect or slightly curve, dark brown, thick-walled, smooth, 1 — 2 septate, tapered gradually towards the acute to pointed apices, up to 190 µm long x 4 — 5 µm wide, with inflated base 10 — 18 µm wide. **Conidiophores** macronematous, mononematous occurring singly or in groups of 2 - 4, arising from aggregated hyphae, simple, rarely branched except occasionally at the base, flexuous, pale brown, smooth and thick-walled, 3 - 5 septate, often constricted at the septa, 20 - 38 µm long, at the base 2.5 - 3 µm wide. **Conidiogenous cells** integrated, terminal, monophialidic, doliiform 8 - 10 µm wide, 8 - 13 µm long with a


A
B
C
D
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large cup-shaped collarette at the apex, 5 - 10 µm wide, 7 - 14 µm deep, proliferating enteroblastically and producing several conidia sub-endogenously at the same level. **Conidia** acrogenous, solitary, subglobose to napiform, smooth, hyaline, thin-walled, 15 - 19 µm across, 13 - 15 µm high and furnished with 4 - 8 thin, hyaline, hairlike, non-septate appendages, 25 - 46 µm long, 0.3 - 0.5 µm wide, arising simultaneously in a circle about 3/4 up the crown of the conidium. **Conidium secession** schizolytic.

The first formed conidium arises as an oval hyaline cell from the apex of the inflated conidiogenous cell. As the conidium enlarges to become subglobose the outer wall is broken and results in a funnel-shaped subhyaline collarette with frayed margin. The conidium at this stage is connected to the conidiogenous cell by a thin isthmus 1 - 1.5 µm across. When the conidium is near maturity, 5 - 8 minute wedge-shaped projections develop in a circle about the crown and these elongate into the long delicate, non-septate appendages with their bases often twisted once or twice. At the same time the crown of the conidium flattens somewhat so that in side view the conidium is smoothly rounded at the base and slightly dented at the crown. The circular, flattened area demarcated by the appendages often appears clear and does not stain readily. Viewed from above the conidium is roundish to angular in outline, with the thickened bases of the appendages clearly visible as small rings arranged in a circle. Viewed from below, a small circular area is often observed in detached conidia, indicating the point of attachment to the conidiogenous cell. This detachment point is not necessarily situated directly at the base of the conidium, but can be to one side depending on the orientation of the developing conidium in the collarette. As soon as a conidium is released, the conidiogenous cell evidently proliferates enteroblastically through the narrow channel to produce additional conidia at the same level within the collarette. Regeneration, however, was not observed. Conidia germinate slowly on agar media. On CMA the colonies are dark, slow growing, attaining a diam of 10 mm in 20 days at 25 - 28°C. No sporulation occurred on dry agar but when strips of the colony were suspended in water conidia and setae were formed abundantly.

This new genus is introduced to accommodate a fungus which shares some similarities in conidial morphology and to some extent conidiogenesis with **Nawawia filiformis** (Nawawi)

Fig. 2. **Obeliospora basispira.** A-D, conidia at various stages of formation; E-H, conidia. Bars = 10 µm.

Marvanová (Nawawi 1973, Marvanová 1980) but differs in the structure of their conidiophore apparatus. Further **N. filiformis** is non-setose. The observed differences are marked and considered to be of sufficient magnitude to warrant separating the two fungi into different genera. In both species, although conidiogenesis is holoblastic with enteroblastic conidiogenous cell, there is a marked difference inasmuch as in **N. filiformis** the conidiophores are long and rigid terminating in a cylindrical conidiogenous cell with broad truncate apex and shorter collarette. The aseptate, aquatic conidia are hyaline, turbinate-tetrahedral or pyramidal with 3 - 4 long hyaline appendages at their blunt apices. Conidia formed outside water are oblong with the obtuse end lacking appendages. The conidiogenous cell may proliferate percurrently to produce conidia at successively higher levels. In **O. basispira** the conidiophores are short, often undulate and the conidiogenous cell is doliiform with distinct collarette and proliferation leads to the formation of conidia at the same level within the deep collarette.

Another fungus which resembles **O. basispira** is the genus **Bahusutrabeeja** Subramanian & Bhat (1977). In **Bahusutrabeeja,** however, the apex of the conidiogenous cell is of similar diameter to the base or only just a little narrower and only minute remains of a collarette resulting from conidial production are visible. Further, the cytoplasmic channel is comparatively wide in relation to the total diameter of the conidiogenous cell which may proliferate percurrently. There is also a marked difference in conidial morphology between the two genera. In **B. dwaya,** the type species, the aseptate conidia are hyaline, globose and with many slender appendages distributed over the entire surface. In addition, the first formed conidium is obpyriform while all others are globose. No such dimorphism occurs in **Obeliospora.**

We are grateful to Professor J. Webster, University of Exeter for reviewing the manuscripts.

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MYCOTAXON

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ON THE CORRECT NAMES FOR SOME SPECIES OF MELANELIA

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The most recent North American lichen checklist (Egan 1987) included four new combinations made by me in the genus *Melanelia*. Unfortunately, only two of these were actually necessary and legitimate combinations. The other two were unnecessary.

First on the list was *Melanelia fuliginosa* (Fr. ex Duby) Essl. Although the existence of an earlier homonym makes the specific epithet *fuliginosa* unavailable for use in *Parmelia* (Esslinger 1977), its legitimacy at the species level dates to the combination *Imbricaria fuliginosa* made by Arnold in 1870. Since this predates the first use of the epithet *glabratula* at the species level (1883), the epithet *fuliginosa* has priority and must therefore be used when this species is placed in *Melanelia* or any genus other than *Parmelia*.

The second new *Melanelia* combination in the checklist, *M. glabra* (Schaer.) Essl., was made for a very different reason. My first attempt to transfer *Parmelia glabra* (Schaer.) Nyl. into *Melanelia* (Esslinger 1978) was thwarted by a typographical error which excluded it from the list of new combinations, even though its basionym was cited. Admittedly, some may feel that a mere typographical error does not invalidate the original 1978 combination. However since the code does not clearly address this type of situation, it was felt that the new combination was still in need of being made.

The last two *Melanelia* combinations made in the checklist, *M. granulosa* (Lynge) Essl. and *M. incolorata* (Parrique) Essl., were based on homonymous names (see Esslinger 1977) with no legitimacy at the species level, and are therefore unnecessary new combinations. *Parmelia granulosa* Lynge was illegitimate when first described, being a later homonym of *P.*

granulosa (Ehrh.) Mart. which dates back to 1817. *Parmelia incolorata* (Parrique) Lett. is an illegitimate later homonym of *P. incolorata* (Hoffm.) Flörke which dates to 1809. When placed in *Melanelia* therefore, the correct names for the two taxa involved are, respectively, *M. disjuncta* (Erichs.) Essl. and *M. elegantula* (Zahlbr.) Essl. as originally presented (Esslinger 1978).

Acknowledgement - I wish to express my gratitude to Dr. Irwin M. Brodo for reviewing this manuscript.

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MYCOTAXON

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MELIOLACEAE OF SOUTH INDIA - VII

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SUMMARY

This paper gives an account of six meliolaceous fungi recently encountered in South India. Amazonia balakrishnanii, Meliola aphanamixidis, M. mannii, and M. nairii are described as new species; M. osyridicola Hansf. var. indica is described as a new variety. Meliola floridensis is reported from India for the first time.

Key words: Meliolaceae, Amazonia, Meliola, black mildews, India

This paper gives an account of six taxa of meliolaceous fungi found in South India which have not been previously reported from this region. Four are considered to be new species, and one is a new variety. The sixth is a new record for India. The materials on which these taxa are based have been deposited in the HCIO, New Delhi.

1. *Amazonia balakrishnanii* Hosagoudar, sp. nov.

Plagulae epiphyllae, subdensae, ad 3 mm diam. Hyphae plerumque rectae, opposite vel alternate acuteque vel laxe ramosae, dense reticulatae, cellulis 15-18.5 x 9-12.5 um. Hyphopodia capitata alternata, antrorsa, 24-28 um longa; cellula basali cuneata, 6-9.5 um longa; cellula apicali versiformia vel cylindracea, integra, 15-18.5 x 12-15.5 um. Hyphopodia mucronata illis capitis commixta, opposita vel alternata, ampullacea, 18-25 x 9-12.5 um. Perithecia mycelio exhyphopodiati insidentia, dispersa, depressa-globosa, ad 118 um; sporae obovoidae vel cylindraceae, 4-septatae, constrictae, 24-43.5 x 21-25 um.

Colonies epiphyllous, subdense, up to 3 mm in diameter. Hyphae mostly straight, branching opposite to alternate at acute to wide angles, closely reticulate, cells 15-18.5 x 9 -12.5 um. Capitate hyphopodia alternate, antrorse, 24-28 um long; stalk cells cuneate, 6-9.5 um long; head cells versiform to cylindrical, entire, 15-18.5 x 12-15.5 um. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 18-25 x 9-12.5 um. Perithecia seated on exhyphopodiate mycelium, scattered, flattened globose, up to 118 um; spores obovoidal to cylindrical, 4-septate, constricted, 34-43.5 x 21-25 um.

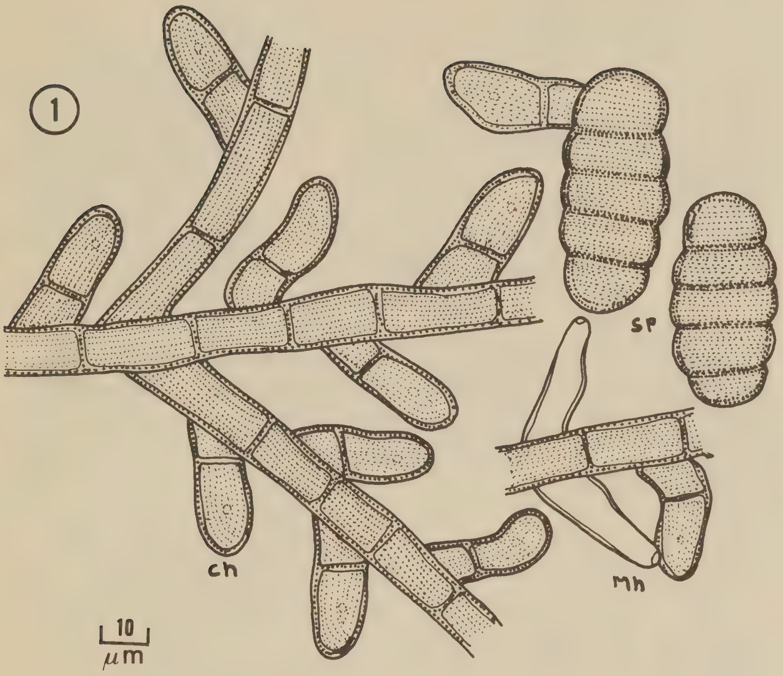
Holotype: On leaves of *Castanopsis armata* Spach (Fagaceae), Assam, Jan., 1987, G. Mann HCIO 39434a.

The colonies of both *Meliola mannii* and *M. balakrishnanii* were found on the same leaf. The latter can be easily distinguished from *M. mannii* by its subdense colonies, robust mycelia, densely arranged capitate hyphopodia and its cylindrical to versiform head cells of the capitate hyphopodia.

There are no prior reports of the genus *Amazonia* on the members of the family Fagaceae. The species is named in honour of Dr. N.P. Balakrishnan for his valuable contributions to knowledge of the angiosperm family Euphorbiaceae.

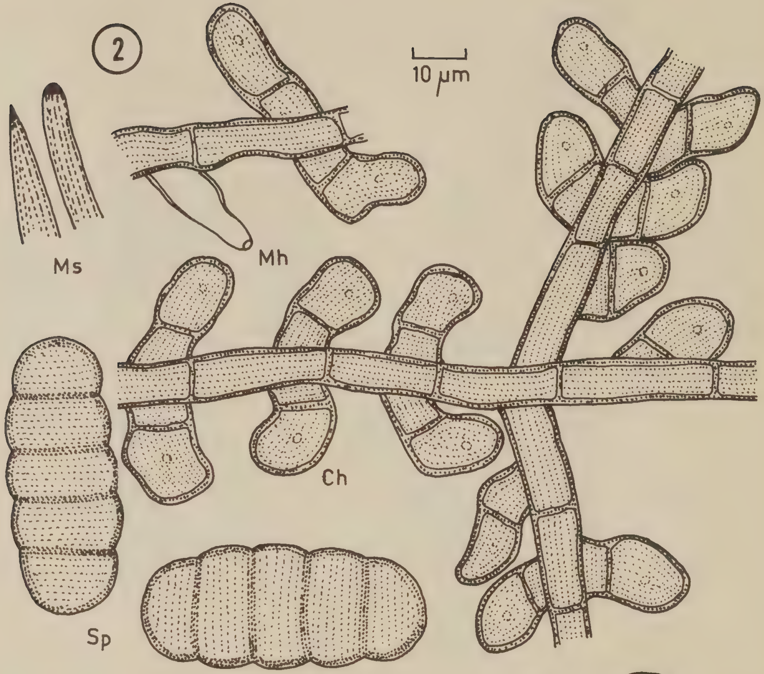
2. *Meliola aphanamixidis* Hosagoudar, sp. nov.

Plagulae epiphyllae, densae, velutinae, ad 2 mm diam., raro confluentes. Hyphae subrectae vel leniter anfractuosae, opposite vel irregulariter lateque ramosae,



Figs. 1 - 5. New taxa of meliolaceous fungi. Key to abbreviations: Ch = capitate hyphopodia. Mh = mucronate hyphopodia. Ms = mycelial setae. Sp = ascospores.

Fig. 1. Amazonia balakrishnanii Hosagoudar.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Ch
Sp

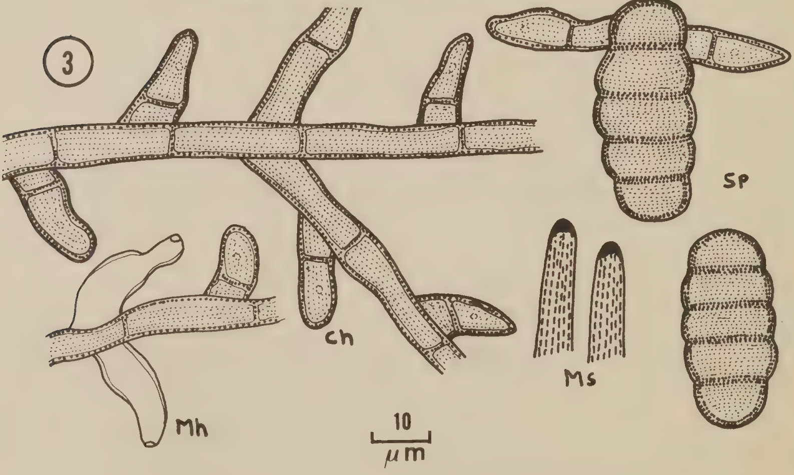
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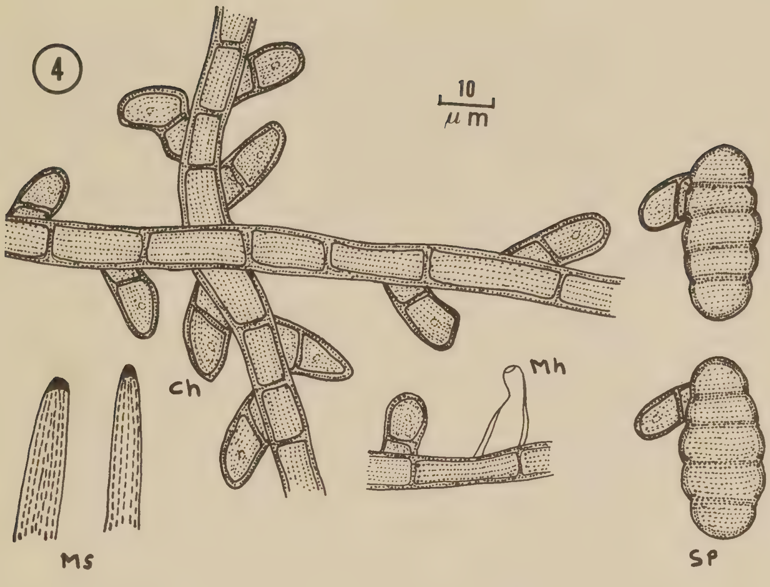
Fig. 2. Meliola aphanamixidis Hosagoudar.

Fig. 3. Meliola mannii Hosagoudar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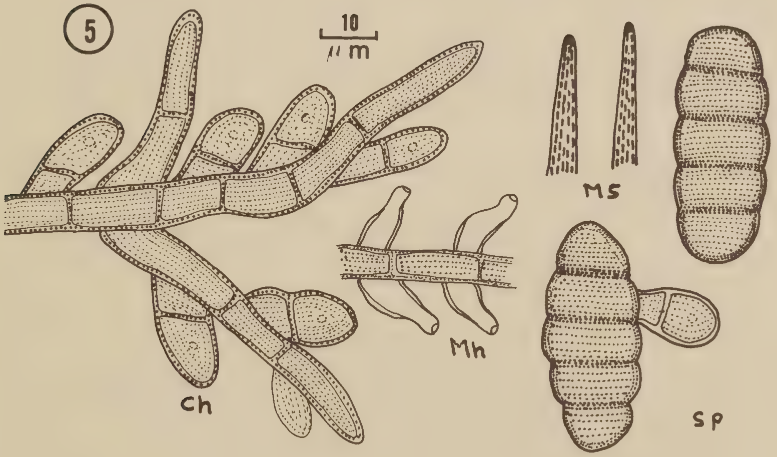
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Fig. 4. *Meliola nairii* Hosagoudar. Fig. 5. *Meliola osyridicola* Hansf. var. *indica* Hosagoudar.

laxe vel densae recticulatae, cellulis 12-28 x 9-12.5 um. Hyphopodia capitata opposita, post spatium dense disposita, rare solitaria, antrorsa, subantrorsa vel recurva, 21-31 um longa; cellula basali cylindracea vel cuneata, 6-12.5 um longa; cellula apicali ovata, angulosa, truncata, recta vel curvala, integra, 15-18.5 x 9-15.5 um. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, 18-25 x 9-12.5 um. Setae myceliales plerumque aggregatae ad peritheciales, simplices, rectae, acutae vel obtusae, ad 572 um longae. Perithecia mycelio exhyphopodiate insidentia, dispersa, verrucosa, ad 232 um; sporae obovoidae, 4-septate, constrictae, 52-56 x 18-22 um.

Colonies epiphyllous, dense, velvety, up to 2 mm in diameter, rarely confluent. Hyphae substraight to slightly crooked, branching opposite to irregular at wide angles, loosely to closely reticulate, cells 12-28 x 9-12.5 um. Capitate hyphopodia opposite, crowded after intervals, rarely solitary, antrorse, subantrorse, recurved, 21-31 um long; stalk cells cylindrical to cuneate, 6-12.5 um long; head cells ovate, globose, angular, truncate, straight to curved, entire, 15-18.5 x 9-15.5 um. Mucronate hyphopodia mixed with capitate hyphopodia, opposite to alternate, ampulliform, 18-25 x 9-12.5 um. Mycelial setae mostly grouped around perithecia, simple, straight, acute to obtuse, up to 572 um long. Perithecia seated on exhyphopodiate mycelia, scattered, verrucose, up to 232 um; spores obovoidal, 4-septate, constricted, 52-56 x 18-22 um.

Holotype: On leaves of Aphanamixis polystachya (Wall.) Parker (Amoora rohituka Wight & Arn.), Devala Rock-wood forest, Nilgiris, T.N., Nov. 23, 1972, E. Vajravelu HCIO 39435.

One species of Meliola, M. amoorae Yates, has been reported on Amoora (Hansford, 1961). This collection differs from M. amoorae in having larger capitate hyphopodia. It can be compared with M. opposita Syd. but differs in the morphology of the capitate hyphopodia and in having larger ascospores.

3. **Meliola floridensis** Hansf., Sydowia 10: 72, 1957.

On leaves of Persea macrantha (Nees) Kosterm. (Lauraceae), Pudukadu, Lowey Sheikalmudi, Coimbatore, T.N., Jan. 17, 1987, V.B. Hosagoudar HCIO 39437

4. **Meliola mannii** Hosagoudar, sp. nov.

Plagulae epiphyllae, tenues, ad 2 mm diam., confluentes. Hyphae mycelii rectae vel subrectae, opposite lateque ramosae, laxe reticulatae, cellulis 31-56 x 7-9.5 um. Hyphopodia capitata alternata, antrorsa, recta, raro curvata, 15-22 um longa; cellula basali cuneata, 3-6 um longa; cellula apicali conoidea, rotundata ad apicem, plerumque recta vel raro curvata, integra, 12-15.5 x 9-12.5 um. Hyphopodia mucronata illis capitatis commixta, alternata vel opposita, ampullacea, 18-25 x 9-12.5 um. Setae myceliales paucae, ad juxta perithecia, rectae, simplices, obtusae, ad 350 um longae. Perithecia in exhyphopodiati mycelia, dispersa, ad 124 um; sporae obovatae vel cylindraceae, 4-septatae, constrictae, 43-45 x 18-22 um.

Colonies epiphyllous, thin, up to 2 mm in diameter confluent. Hyphae straight to substraight, branching mostly opposite at wide angles, loosely reticulate, cells 31-56 x 7-9.5 um. Capitate hyphopodia alternate, straight, rarely curved, 15-22 um long; stalk cells cuneate, 3-6 um long; head cells ovate, pointed and rounded towards the apex, mostly straight but rarely recurved, entire, 12-15.5 x 9-12.5 um. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 18-25 x 9-12.5 um. Mycelial setae very few, grouped around perithecia, simple, straight, obtuse, up to 350 um long. Perithecia seated on exhyphopodiate mycelium, scattered, up to 124 um; spores obovate to cylindrical, 4-septate, strongly constricted, 43-45 x 18-22 um.

Holotype: On leaves of Castanopsis armata Spach (Fagaceae), Assam. Jan. 1987, G. Mann HCIO 39434b.

This collection differs from other Meliola spp. reported on Fagaceae in that it forms thin, epiphyllous colonies, and the head cells of the capitate hyphopodia are conoid.

This fungus was noticed on a leaf of herbarium material deposited in the Madras Herbarium. The species is named in honour of the collector.

5. **Meliola nairii** Hosagoudar, sp. nov.

Plagulae epiphyllae, minutae, subdensae, ad 2 mm diam. Hyphae rectae, subrectae vel flexuosae, opposite vel irregulariter lateque ramosae, laxe reticulatae, cellulis 18-31 x 6-9.5 um. Hyphopodia capitata alternata, antrorsa vel subantrorsa, 12-15.5 um; cellula basali cuneata vel cylindracea, 3-6 um longa; cellula spicali ovata, late rotundata ad spices, recta vel curvula, integra, 9-12.5 x 6-9.5 um. Hyphopodia mucronata illis capitatis commixta, opposita vel alternata, ampullacea, 18-22 x 9-12.5 um. Setae myceliales paucae, aggregatae ad peritheciae, rectae, flexuosae, acute vel obtusae, ad 310 um longae. Perithecia dispersa, verrucosa, ad 155 um; sporae obovoidae, 4-septatae, constrictae, 31-34 x 15-18.5 um.

Colonies epiphyllous, minute, subdense, up to 2 mm in diameter. Hyphae straight, substraight to flexuous, branching opposite to irregular at wide angles, loosely reticulate, cells 18-31 x 6-9.5 um. Capitate hyphopodia alternate, antrorse to subantrorse, 12-15.5 um; stalk cells cylindrical to cuneate, 3-6 um long; head cells ovate, broadly rounded at the apex, straight to curved, entire, 9-12.5 x 6-9.5 um. Mucronate hyphopodia mixed with capitate hyphopodia, alternate to opposite, ampulliform, 18-22 x 9-12.5 um. Mycelial setae very few, grouped around perithecia, straight, flexuous, acute to obtuse, up to 310 um long. Perithecia scattered, verrucose, up to 155 um; spores obovoidal, 4-septate, constricted, 31-34 x 15-18.5 um.

Holotype: On leaves of *Aphanamixis polystachya* (Wall.) Parker (Amoora rohituka W. & A.), Panthenthode forest, Palghat, Kerala, Oct. 9, 1972, N.C. Nair HCIO 39439.

This species shows similarites to *M. quareiella* Hansf., reported on *Guarea* sp. from Argentina (Hansford 1961), but differs in having ovate head cells of the capitate hyphopodia and straight to flexuous mycelial setae.

The species is named in honour of Dr. N.C. Nair, former Joint Director, Botanical Survey of India, Southern Circle, Coimbatore, for his valuable contributions to the field of botany.

6. *Meliola osyridicola* Hansf. var. *indica* Hosagoudar, var. nov.

Differt a var. *osyridicola* hyphopodiis mucronatis in hyphis distinctis evolutis.

Colonies amphigenous, mostly epiphyllous, dense, velvety, up to 2 mm in diameter, rarely confluent. Hyphae substraight to flexuous, branching opposite to irregular at acute angles, closely reticulate and forming a solid mycelial mat, cells 12-22 x 7-9.5 um. Capitate hyphopodia alternate to unilateral, straight to closely antrorse, 18-25 um long; stalk cells cuneate, 6-12.5 um long; head cells globose, ovate, entire, 9-15.5 x 12-15.5 um. Mucronate hyphopodia borne on a separate mycelial branch, mostly opposite, ampulliform, 15-19 x 9-12.5 um. Mycelial setae numerous, scattered, straight, simple, very thin, acute to obtuse, up to 150 um long. Perithecia scattered, verrucose, up to 140 um; spores obovoid, 4-septate, constricted, 43-46.5 x 15-18.5 um.

Holotype: On leaves of *Osyris quadripartita* Salz. ex Decne, National Orchidarium, Yercaud, Tamil Nadu, March 1, 1984, V.B. Hosagoudar MH 80359. Isotype: HCIO 39440.

Meliola osyridis Doidge, *M. osyridis* Doidge var. *karamojensis* Hansf. and *M. osyridicola* Hansf. have been reported on the host *Osyris* (Hansford 1961). The new variety is similar to *M. osyridiciola* Hansf., which has been reported from India, but differs from the type variety in having mucronate hyphopodia borne on a separate mycelial branch, smaller capitate hyphopodia, mycelial setae, perithecia and ascospores.

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NEW AUSTRALASIAN SPECIES AND RECORDS IN THE GENUS LEPTOGIUM S. GRAY (LICHENIZED ASCOMYCOTINA: COLLEMATACEAE)

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Abstract: The following species are described: *Leptogium enkarodes* Verdon (Papua New Guinea, Australia), *L. faciifictum* Verdon (Aust.), *L. pellobatum* Verdon (Aust.), *L. poliophaeum* Verdon (Aust.), *L. rogersii* Verdon (Aust.) and *L. streimannii* Verdon (PNG). Several new Australasian records are reported, viz.: *L. austroamericanum* (Malme) Dodge (Aust.), *L. biloculare* F.Wilson (New Zealand), *L. bullatulum* Müll. Arg. (PNG), *L. coralloideum* (Meyen et Flotow) Vainio (Aust., NZ, PNG), *L. corniculatum* (Hoffman) Minks (Aust.), *L. fallax* Müll. Arg. (Aust., PNG). The description of *L. bullatulum* Müll. Arg. is emended. Taxa described by F. R. M. Wilson in the late nineteenth century are discussed and lectotypes of *L. biloculare* F. Wilson, *L. chloromelum* var. *victorianum* F.Wilson, *L. inflexum* var. *limbatum* F. Wilson, *L. limbatum* F. Wilson, *L. pecten* F. Wilson, *L. philorheuma* F. Wilson, *L. tremelloides* var. *muscitegens* F. Wilson [= *Collema subconveniens* Nyl.], and *L. victorianum* F. Wilson are selected.

Introduction

No serious study of Australian *Leptogium* species has been undertaken since the late nineteenth century. In that period of increasing interest in the Australian flora Rev. F. R. M. Wilson described many new Australian lichens, among which were sixteen *Leptogium* taxa (Wilson, 1889 to 1893). In the early twentieth century, however, Vainio (1920) published his Lichenes of the Philippine Islands which included several new *Leptogium* species. This work, plus Sierk's revision of the North American *Leptogium* species (Sierk, 1964), studies of the "mallotium" group by Jørgensen (1973a,b, 1975) and a revision of the *L. azureum* group in Western Europe by Jørgensen and James (1983), have provided the basis for a revision of the Australian species. The new species and records in this paper result from study for such a revision, but there are still problematic taxa which require further study.

Materials and Methods

Micro-photographs were taken using differential interference contrast techniques with a Zeiss Photoscope III microscope. Kodak Pan X Film at 32 ASA was used and developed in Ilford Microphen solution.

Anatomical studies were made using sections cut with a freezing microtome; sections usually were 6-14 µm thick, but in species with a loosely structured medulla (e.g. *L. enkarodes*) sections 20-30 µm thick were also taken. Sections were mounted in lactophenol-cotton blue for semi-permanent slides, but where possible measurements were made using water mounts. Temporary mounts of apothecial sections also were made in a weak 'I' solution, viz.: 0.5g I + 2g KI in 300ml of 30% lactic acid in distilled water. Studies of spores were made with apothecial squashes in water mounts and studies of pycnidia with sections and squashes in ammoniacal erythrosin.

The following abbreviations are used below when citing specimens: J.A.E. - J. A. Elix; M.E.H. - M. E. Hale; R.W.R. - R. W. Rogers; G.N.S. - G. N. Stevens; H.S. - H. Streimann and D.V. - D. Verdon. Unless stated otherwise specimens collected by J.A.E. are at ANUC, by M.E.H. at US, by R.W.R. or G.N.S. at BRIU and by H.S. or D.V. at CBG.

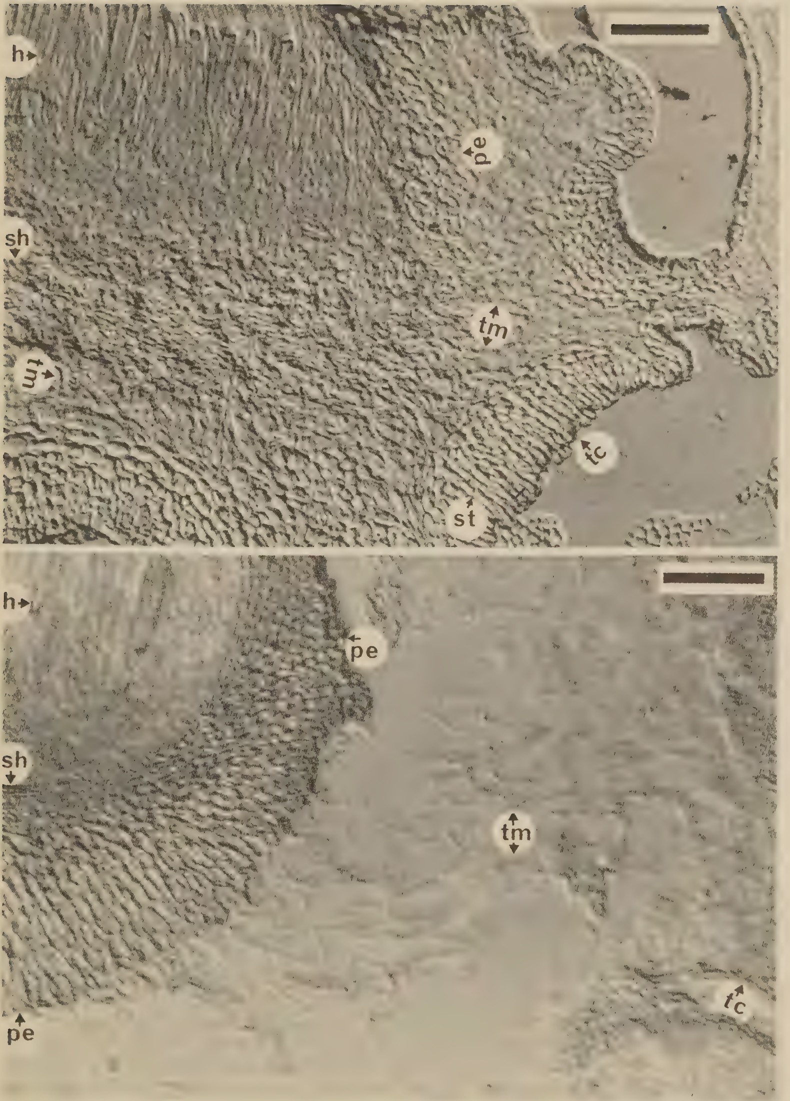
Leptogium enkarodes Verdon sp. nov. Figures 1 & 8.

Hoc quoad lobos incrassatos ad *L. chloromelum* similari sed ab eo apotheciis maturis in textura thallina elevata usque ad summum eorum marginum thallinorum immersis, medullis excipuli thallini tenuibus, cortice in parte basali et eius textura fulcranti paraplectenchymata 70-150 µm crassa, excipulis propriis in parte basali e hyphis periclinalibus debiliter fabricatis vel absentibus differt.

Type. Papua New Guinea. Central Province. On large *Schefflera* stem, *Eucalyptus* dominated savannah woodlands, Mt. Lawes, 18 km NW of Port Moresby, 7°26'S 147°07'E, 200m, H. Streimann 14694, 5 Feb.1981; holotype, CBG; isotypes, LAE, H.

Thallus corticolous, foliose, irregular, sometimes confusedly so, subpulvinate to pulvinate, conduplicate with erect sides or undulate to plicate, younger parts ± spreading, with ascending margins, irregularly lobate, (0.7-)1-4(-5) cm wide; *lobes* sometimes anastomosing, rotund to oblong, ascending to erect, variably concave to convex, undulate or plicate, sometimes conduplicate and twisted, variably thickened; *margins* entire, strongly wrinkled and ridged or thickened, undulate to plico-undulate, sometimes poorly defined; *upper surface* usually lead-grey, intricately and prominently wrinkled or ridged, isidia absent; *wrinkles* anastomosing, curved or undulate to strongly plicate, sometimes forming irregular, pycnidia-tipped lobules, in older parts sometimes stramineous and appearing fibrous, *lower surface* similar and concolorous, attached by direct contact or by inconspicuous rhizines; *Apothecia* (1.5-)2-3(-4) mm diameter, submarginal but often appearing terminal due to recurved apices of fertile lobes, which are sometimes stipe-like due to recurved, partially connate margins, immersed in thickened raised tissue to top of the thalline margin or this tissue projected above margin and incurved; *thalline margin* pale tan to cream; *disc* concave to plane, reddish-brown; *pycnidia* submarginal to marginal, immersed, apices emergent, papilliform, concolorous with thallus or brownish, ostiole brown.

Anatomy. *Thallus* extremely variable in thickness due to ridges and thickening, 70 - 500 µm thick; *cortex cells* spherical to spherico-oblong in section, 5-10 µm diameter; *medulla* of very loosely interwoven hyphae 2-5 µm diameter and with ±periclinal orientation, anticlinal supporting hyphae absent; *photobiont cells* spherical to transversely oval or broadly so, 5-7 µm diameter or 5-7 x 2-4 µm, discrete and scattered to very densely clustered or in chains of 2-6. *Apothecia* (200-)260-400(-450) µm thick; *thalline exciple* basal part (80-)90-180(-190) µm thick, marginal part (50-)60-150(-160) µm thick; *cortex* with paraplectenchymatous supporting tissue, basal part (50-)70-150(-180) µm thick, inner cells (3-6 layers) irregularly spherical in section, (12-)15-20(-23) µm diameter, outer cells (4-6 layers) oblong to narrow-oblong in section, anticlinally oriented, (7-)9-16(-18) x 5-8 µm; marginal part 30-120 µm thick, cells as in basal part; *proper exciple* basal part poorly developed, with 1-3 layers of periclinal hyphae or absent, marginal part ±subparaplectenchymatous to paraplectenchymatous above and merging with thalline excipular cortex, (15-)20-60(-65) µm thick; *subhymenium* 50-90 µm thick, very pale yellow, formed of densely interwoven hyphae with general periclinal orientation; *hymenium* hyaline,with pale brownish epihymenium, 150-200 µm thick; *paraphyses* to 2.4 µm diameter, apices slighty swollen, 3-5 µm diameter; *asci* cylindrico-clavulate, 100-140 µm long; *spores* 8, mono- or irregularly distichous, ellipsoid to broad-ellipsoid with ±broad acute apices, 22-35 x 12-15 µm, muriform at



Figures 1-2. Comparative transverse vertical sections of apothecia: 1, *L. enkarodes* (holotype); 2, *L. chloromelum* (Sw.) Nyl.(neotype); h = hymenium, pe = proper exciple, sh = subhymenium, st = supporting tissue, tc = thalline excipular cortex, tm = thalline excipular medulla. Scale lines = 50 µm.

maturity, with 4-5 lateral and 1-2 longitudinal septa; *pycnidia* globular to slightly depressed-globular, 150-200(-250) µm diameter, *conidia* bacilliform, usually with swollen ends, 2-4(-5) x c.1 µm.

Specimens examined:
PAPUA NEW GUINEA. CENTRAL PROVINCE. On stump of half-dead *Fagraea, Eucalyptus* dominated savannah woodlands, Mt. Lawes, 18 km NW of Port Moresby, 7°26'S 147°07'E, 200m, H.S. 14688, 5.ii.1981.
AUSTRALIA. QUEENSLAND. On *Denhamia oleaster,* in *Eucalyptus* dominated grassland, Cooktown Road, 3km NW of Mt. Molloy, 16°40'S 145°19'E, 450m, J.A.E. 17162 & H.S., 3.viii. 1984; on base of *Alphitonia*, along the track in poor rainforest, O'Keefe Creek, Big Tableland, 26 km S of Cooktown, 15°43'S 145°15'E, 370m, J.A.E. 17333 & H.S., 4.vii.1984.

Leptogium enkarodes appears to be a rare species in both Papua New Guinea and Australia and so far has only been collected in savannah habitats or at the edge of poor rainforest. It has irregularly thickened thallus lobes and may be confused with *L. chloromelum* (Sw.) Nyl. but its apothecia are immersed up to the thalline margin in thickened lobe tissue. Its apothecium also has a thinner thalline exciple with the cortex supported by a thick paraplectenchymatous tissue (fig. 1) and a proper exciple that is weakly formed of periclinal hyphae or absent in the basal part.

Development of the raised tissue which surrounds the apothecium in this species seems to be similar to the stipe development in *L. javanicum* (see under *L. pellobatum*) but it is ±solid, probably due to the lobe thickening. Further study of apothecial development in *L. enkarodes* is needed to evaluate the process.

The epithet *enkarodes* is from the Greek enkaros (ενκαροσ), brain, with the suffix -odes (-οδεσ) to indicate resemblance; referring to the plicate wrinkles of this species which appear convoluted and somewhat brain-like.

Leptogium faciifictum Verdon sp. nov. Figures 4, 5 & 9.

Hoc cum *L. coralloideum* interdum confusum sed ab eo rugis crassioribus, raro lamelloideis isidiis crassioribus raro coralloideis, apotheciis parvioribus, ad maturitatem solum partibus basalibus in textura thallina elevata immersis, excipulis propriis partibus basalibus e hyphis periclinalibus debiliter fabricatis vel absentibus, sporis parvioribus differt.

Type. Australia. Queensland. On trees along the foreshore, Green Island, 27.5 km NE of Cairns, [16°46' S 145°58' E], sea level, J. A. Elix 2592, 26.viii.1976; holotype, CBG ; isotype, MEL.

Thallus corticolous, foliose, ±spreading with erect margins or pulvinate, 2-6 cm wide, irregularly lobate; *lobes* rotund to oblong or sometimes narrow-oblong, concave to undulate, ±ascending to erect, contiguous to imbricate, (1.5-)2-3.5(-4) mm wide, *margins* undulate to plico-undulate, entire or sparsely to densely isidiate; *upper surface* lead-grey to darkish lead-grey or sometimes blackening, moderately to very prominently wrinkled, with ±anastomosing, usually obtuse and, rarely, lamelloid wrinkles, sparsely to densely isidiate; *isidia* cylindrical or thickening and rarely becoming flattened, simple to branched or rarely coralloid; *lower surface* similar and concolorous with or paler than upper surface but rarely isidiate, attached to substrate by inconspicuous hapters or rhizines. *Apothecia* laminal to submarginal, 1.5-2(-2.5) µm diameter, developed in small, ±isidiate bullae and remaining immersed when young with pale base visible in corresponding hollow on underside, then emerging, rarely obliquely so, only bases immersed at maturity, or becoming adnate; *thalline margin* cream to pale tan, prominent above disc or level with it at maturity, densely isidiate or sometimes adorned with remnants of upper parts of bulla; *disc* concave to plane at maturity, reddish-brown; *pycnidia* not seen.

Anatomy. *Thallus* (90-)100-280(-300) µm thick; *wrinkles* usually oblong to obovate in transverse section; *cortical cells* irregularly spherical to spherico-oblong in section, 7-12(-15) µm diameter; *medulla* loosely structured of ±periclinally oriented, interwoven hyphae, anticlinal supporting hyphae sparse or absent; *photobiont cells* ±spherical, 4-5 µm diameter, discrete and scattered to clustered or in chains of 3-6. *Apothecia* 300-450(-500) µm thick; *thalline exciple* basal part (80-)100-200(-250) µm thick; *cortex* with paraplectenchymatous supporting tissue, basal part 70-150 µm thick, marginal part (20-)30-70(-80) µm thick, cells isodiametric or ±oblong in section and anticlinally oriented, 10-20 µm diameter or 10-20 x 7-12 µm; *medulla* moderately well structured with many anticlinal or radiating hyphae; *photobiont cells* as in thallus but sparse; *proper exciple* basal part poorly formed of periclinal hyphae or absent, marginal part of periclinal hyphae, becoming subparaplectenchymatous above then blending into the incurved thalline excipular cortex, (10-)15-40(-60) µm thick; *subhymenium* (50-)65-100(-125) µm thick, yellowish, of densely interwoven hyphae; *hymenium* (170-)180-200(-230) µm thick, hyaline with brownish epihymenium; *paraphyses* 2-3 µm diameter, apices slightly swollen, 2.5-5 µm diameter; *asci* cylindrical to cylindrico-clavulate, (140-)150-185 (-200) µm long; *spores* ellipsoid with acute to rarely slightly obtuse ends, (20-)25-28 (-30) x 10-13 µm, submuriform to muriform with 3-5 lateral septa and 1(2) longitudinal septum.

Specimens examined:
AUSTRALIA. QUEENSLAND. On trees along the foreshore, Ellis Beach, 16°44'S 145°39'E, sea level, J.A.E. 2567, 25.viii.1976; on trees along foreshore, Green Island, 27.5 km NE of Cairns, [16°46'S 145°58'E], sea level, J.A.E. 2579, 26.viii.1976; on tree trunk, in scrubby *Glochidion* dominated rainforest, Proserpine River Valley, 20 km WNW of Proserpine, 20°22'S 148°24'E, 150m , J.A.E. 21111 & H.S., 2.vii.1986; wet sclerophyll forest, Samford-Mt. Glorious PEI road, c. 2 km N of Highvale, 27°22'S, 152°47'E, 250m, J. Johnston 1315, 28.viii.1984(ANUC); twigs of *Leucopogon*, in a eucalypt forest, State Forest, 8 km west of Imbil, [c. 26°28'S 152°41'E], R.W.R. 2088, 10.v.1979; bark of rainforest tree, softwood scrub near Yabba Rd., 6 km north of Jimna, [c. 26°40'S 152°28'E], 650m, R.W.R. 2261[A], 4.v.1981; on *Avicennia*, Mud Is., N side of creek, s.l., G.N.S. 2758, 8.viii.1978; on a large boulder, *Eucalyptus* dominated grasslands on steep, boulder strewn hillside, Gillies Highway, 12 km SW of Gordonvale, 17°09'S 145°43'E, 300m, H.S. 30055, 28.vi.1984; on base of strangling *Ficus*, *Eucalyptus* dominated grassland on rocky, gently sloping hillside, Stoney Creek, Cooktown Road, 4 km NW of Mount Molloy, 16°40'S 145°18'E, 450m, H.S. 30676, on rock in the creek, *Eucalyptus-Acacia* shaded, rocky, seasonal stream, [loc. cit.], H.S. 30698, 3.vii.1984; on *Leptospermum*, disturbed *Eucalyptus* woodland, Mt. Stuart, 10 km SSW of Townsville, 19°21'S 146°47'E, 570m, HS 37777, 3.vii.1986; on large *Ficus* trunk, rainforest with *Ficus macrophyllus* dominant, rocky hillside, moderate to steep slope, NE aspect, Burleigh Heads, 28°05'S 153°27'E, 150m, D.V. 5198, 5202, 23.i.1983; on bark, Bedarra Island, south of Dunk Island, 17°57'S 146°09'E, coll. J. M. Gilbert (Bratt Herb. 75/803,) 16.vii.1975(HO); on hill, Magnetic Island, 19°08'S 146°50'E, J. M. Gilbert (Bratt Herb. 75/829), 7.viii.1975(HO); mangrove and strand forest, Edmund Kennedy National Park, on Clift Road, NW of Cardwell, sea level, M.E.H. 69136, 27.vii.1983; mangrove area with granite outcrops, Cape Cleveland National Park, E of Townsville, M.E.H. 69121, 29.vii.1983.
NEW SOUTH WALES. On rainforest tree, Bruxner Park, 9 km NW of Coffs Harbour, 30°15'S 153°07'E, 180m, J.A.E. 3489A, 1.vii.1977; on huge old *Avicennia* at waters edge, Ballina-Fishery Ck., [c. 28°52'S 153°34'E], s.l., G.N.S. 1957, 26.viii.1977.

Leptogium faciifictum is a widespread species in lowland and montane, coastal or subcoastal regions of Queensland and also occurs in northern New South Wales. It grows in various habitats but more often in habitats such as savannah, disturbed or open rainforest or strand forest than in undisturbed rainforest, although it is sometimes found in the more open parts of the latter.

The species epithet is from the Latin facies, 'appearance' and fictus, 'false'. It refers to the possible confusion of some forms with other species. For example: more strongly wrinkled and densely isidiate specimens may be confused with *L. coralloideum,* but specimens can usually be separated from the latter by the thicker wrinkles which are rarely lamelloid, and by the thicker isidia which are rarely coralloid. When fertile it can be more confidently separated from *L. coralloideum* by the basal part of its apothecial proper exciple, which is poorly formed of periclinal hyphae or absent, and by the thalline excipular cortex with its well developed paraplectenchymatous tissue (figs. 4 & 5). Small, sparsely isidiate specimens also may be confused with *L. bullatulum* in the fertile state because the apothecia are developed in small bullae and sometimes partially immersed at maturity (although rarely obliquely so) as in that species. It is distinguished from *L. bullatulum*, however, by its more prominent wrinkles and its isidia which, although sometimes sparse, are always present.

L. faciifictum may sometimes be confused with *L. austroamericanum* when sterile. In the fertile state, however, the former can be recognized by its apothecia being at least partially immersed in small bullae and by the structure of its proper exciple - especially the basal part which is never formed of paraplectenchymatous tissue. In the latter species the basal part of the proper exciple is sometimes thin but it is usually paraplectenchymatous and may be up to 100 µm thick in the centre.

Leptogium pellobatum Verdon sp. nov. Figures 3 & 10.

Hoc *L. javanico* var. *microlobo* Vainio affine sed ab eo thallo tenuiore, colore olivaceo, absentia rugarum, margine thallino apothecii lobulato vel fimbriato, stipite apotheciali maturi lobulato et cum lobis accessoriis differt.

Type. Australia. Queensland. Along the margin of stunted rainforest, on *Cyathea*, Big Tableland, 26 km S of Cooktown, 15°43'S 145°17'E, 610m, J. A. Elix 17246, 4.vii.1984; holotype, CBG; isotype, MEL.

Thallus corticolous or sometimes saxicolous, foliose, thin, undulate to ±strongly plico-undulate, irregularly lobate, 1-5 cm wide; *lobes* plane to concave, rotund to oblong, undulate to plico-undulate, 1.5-3(-4) mm broad; *margins* lobulate with simple or branched, rotund to oblong lobules or these rarely sparse; *upper surface* olivaceous to olivaceo-lead-grey, smooth to slightly roughened; often with ±branched lobules and accessory lobes, these sometimes fertile, isidia absent; *lower surface* similar but rarely with lobules or accessory lobes, concolorous or a little paler, ±loosely attached to substrate by direct contact or inconspicuous rhizines. *Apothecia* laminal, (0.8-)1-1.5(-2) mm diameter, initially immersed in small bullae, with pale base visible in corresponding cavity on lobe underside, remaining immersed as bullae extend vertically to form hollow, ±dilated, plicate stipes, but soon emerging, *stipe* attached near margin of thalline excipular base at maturity, then lacerate, with ±branched lobules and accessory lobes; *thalline margin* pale cream to brownish, sometimes lobulate or fringed; *disc* concave to plane at maturity, brown to reddish-brown; *pycnidia* submarginal, immersed, apex emergent, papilliform, concolorous with thallus or brownish, orifice brown.

Anatomy. *Thallus* (28-)30-50(-55) µm thick, *cortex cells* ±spherical in section, (6-)7-12(-15) µm diameter; *medulla* of moderately loosely interwoven hyphae 2-3 µm diameter, mostly with periclinal orientation but with occasional anticlinal 'cortex to cortex' hyphae; *photobiont cells* spherical to transversely oval or broadly so, 4-6 µm diameter or 3-4 x 7 µm, discrete to clustered or in chains of 3-6. *Apothecia* (340-)370-470(-500) µm thick; *thalline exciple* (125-)130-175(-190) µm thick; *cortex* basal part with paraplectenchymatous supporting tissue (70-)100-150(-180) µm thick, inner cells (2-4 rows) ±spherical in section, (13-)18-20(-25) µm diameter, outer cells (2-5 rows) oblong to narrow-oblong in section, 15-25 x 5-10 µm, marginal part (20-)25-80(-100) µm thick, cells as in basal part; *medulla* very thin or absent, similar to thallus but with many radiating hyphae; *proper exciple* basal part poorly formed of periclinal hyphae or absent, marginal part of subparaplectenchymatous tissue 15-25 µm thick; *subhymenium*

45-100 μm thick, of densely interwoven hyphae, yellowish; *hymenium* hyaline with yellowish epihymenium, 200-300(-350) μm thick; *paraphyses* 2-3 μm diameter, with swollen apices, 4-7 μm diameter; *asci* cylindrico-clavulate, 180-300 μm long; *spores* usually 8, mono- to irregularly distichous, ellipsoid with acute to obtuse apices, submuriform to weakly muriform, with 4-5 lateral septa and 0-1 longitudinal septum, (20-)25-35(-40) x 10-13 μm; *pycnidia* depressed-globular, 180 x 120 μm; *conidia* bacilliform, 2 - 3 x c.1 μm.

Specimens examined:
AUSTRALIA. QUEENSLAND. On *Cerbera*, in dense rainforest, Cooroo Logging Area, 16 km WNW of Innisfail, 17°31'S 145°53'E, 100m, J.A.E. 16700 & H.S., 28.vi.1984; on *Cryptocarya*, in rainforest, Main Coast Range, Windmill Creek, 14 km NNW of Mt. Molloy, 16°34'S 145°17'E, 1000m, J.A.E. 16963 & H.S., 30.vi.1984; on saplings, along the rainforest margin, Kirrima State Forest, Cardwell Range, Dunn Creek, 23 km WNW of Cardwell, 18°12'S 145°49'E, 730m, J.A.E. 17623 & H.S., 8.vii.1984; on rocks in Lauraceae-*Syzygium* dominated forest, Mt. Spec State Forest, Paluma Range, 6 km W of Paluma, 19°01'S 146°09'E, 920m, J.A.E 20275 & H.S., 18.vi.1986; on fallen tree branch, poor lowland rainforest, Wright Creek, Lake Eacham, 16 km E of Atherton, 17°17'S 145°38'E, 800m, H.S. 16901, 28.ii.1983.

In most *Leptogium* species that have stipitate apothecia, the stipe is a ±regular cylindrical structure that is often dilated and developed from an initial bulla. It is formed by a continued upward growth of thalline tissue following the formation of the thalline exciple and, as such, its wall is an extension of the thallus with the inner and outer

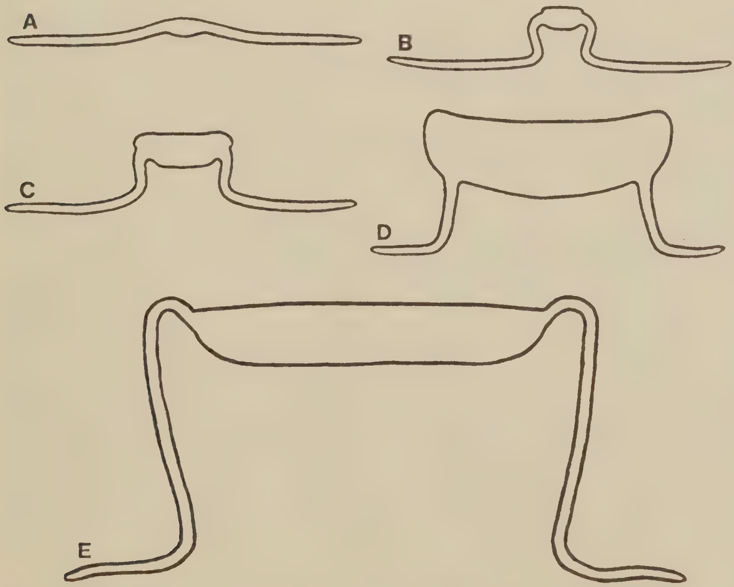


Figure 3. Diagrammatic illustration showing development of apothecium and stipe in *L. pellobatum* (A-D) and mature apothecium of *L. javanicum* (E): A, bulla stage; B, young stipe with emerging apothecium; C, advanced stage of emergence; D, mature apothecium and stipe.

cortex formed respectively from the lower and upper cortex of the latter (fig. 3).The stipes of taxa in the *L. javanicum* group are usually vertically plicate and the initial bullae are often variable in size. In *L. javanicum* Mont. var. *javanicum* Vainio, for example, the bullae are sometimes large and significant, but in *L. pellobatum* and *L. javanicum* var. *microlobum* they are relatively much smaller and sometimes insignificant. A more important diagnostic character, however, is the position of stipe attachment to the mature apothecium. The apothecia of *L. javanicum* var. *javanicum,* for example, remain immersed in the stipe-forming thalline tissue throughout development and at maturity this tissue completely surrounds its thalline exciple; thus the stipe is attached at the thalline margin (fig. 1e). *L. pellobatum* and other taxa such as *L. javanicum* var. *microlobum*, however, differ in that the apothecia emerge from the stipe-forming tissue when still young (fig. 1c) and at maturity the stipe is attached at the outer basal part of the thalline exciple (fig.1d). In addition *L. pellobatum* and *L. javanicum* var. *microlobum* have smaller apothecia and narrower lobes than *L. javanicum* var. *javanicum.*

L. javanicum var. *microlobum* differs from *L. pellobatum* by its thicker, wrinkled thallus, its apothecial thalline margin which is neither lobulate nor fimbriate and its lack of accessory lobes. It probably also differs sufficiently from *L. javanicum* var. *javanicum* to warrant specific rank but recombination should be part of a wider study of the *L. javanicum* group.

The epithet *pellobatum* is from the Latin lobatus with the prefix pel- from per, referring to the accessory lobes that are often present in this species.

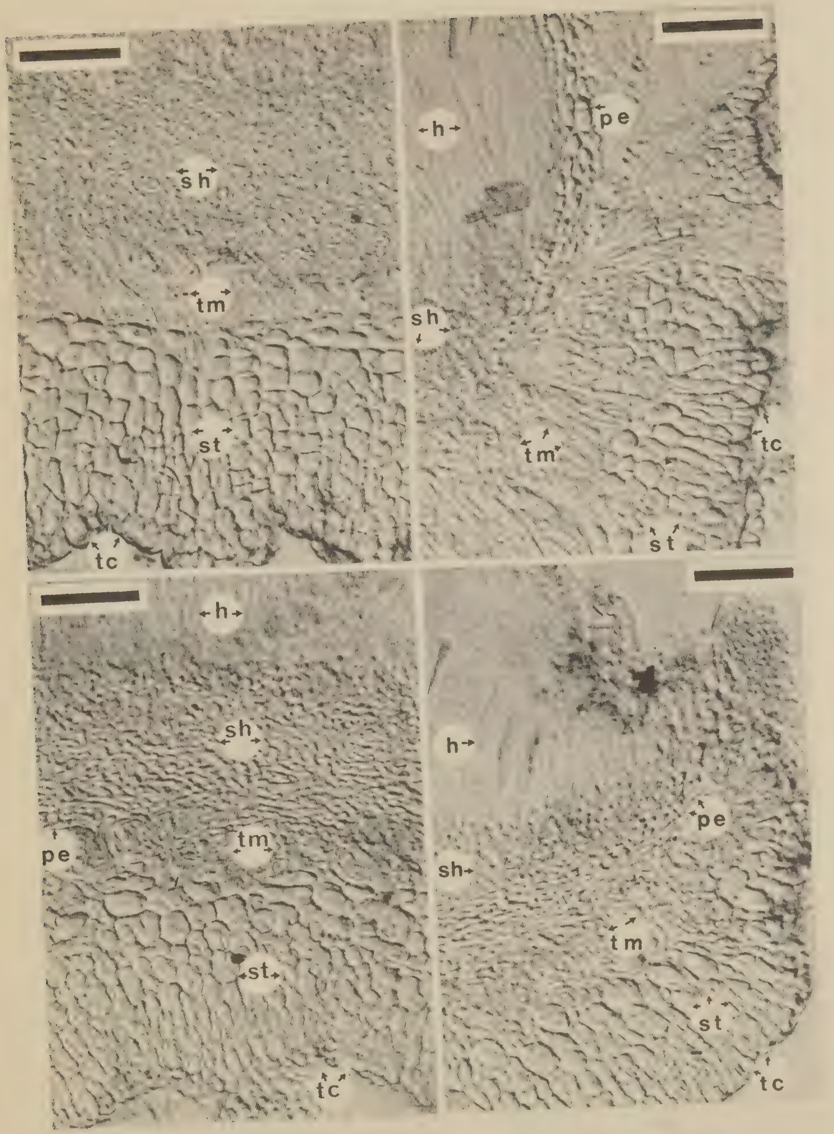
Leptogium poliophaeum Verdon sp. nov. Figures 6, 7 & 11.

Thallus tenuis, parvus, orbicularis vel irregularis, obscuro- ad atrogriseus, isidiatus; isidiis squamuliformis; lobi ±orbiculares, vulgo ad 2.5 mm diameter, apothecia parva (vulgo ad 1 mm diameter) cum marginibus thallinis albidis, non isidatis et exipulis propriis e hyphis periclinalibus omnino fabricatis; cortex excipuli thallini cum textura fulcrante paraplectenchymata, 30-100 μm crassa; sporae ellipsoidea ad elipsoideae angustae, 17-25 x 6-10 μm.

Type. Australia. Queensland. Extensive on large liane stem close to forest floor, strand forest with *Terminalia* spp., *Myristica insipida* and *Pandanus tectorius,* Clump Point, 21 km NE of Tully, 17°52'S 146°07'E, 1m, D.Verdon 5306, 31.Jan.1983; holotype, CBG; isotype, H.

Thallus corticolous, lignicolous or rarely saxicolous, foliose, ±orbicular or irregular, closely adnate to substrate, but lobe ends and margins sometimes raised, 0.4-2 cm wide or coalescing to form irregular composite thalli to 5 cm wide; *lobes* ±orbicular or here and there obovate to broadly obovate, plane to slightly concave or rarely becoming convex, 0.5-2.5(-3.5) mm broad; *margins* entire, sinuate, lobulate or isidiate, sometimes a little undulate; *upper surface* dull to dark grey, usually matt, smooth to a little rough, slightly foveolate here and there, sparsely to moderately isidiate and sometimes with lobules; *isidia* squamuliform, sometimes thickly cylindrical when young; *lower surface* similar to upper but rarely isidiate or lobulate, usually concolorous, attached to substrate by direct contact or inconspicuous rhizines. *Apothecia* laminal, sessile or very shortly stipitate, 0.5-1(-1.3) mm diameter; *thalline margin* pale cream to whitish, not isidiate, prominent in young apothecia, thin to very thin at maturity; *disc* pale orange to faint orange, concave to plane at maturity; *pycnidia* submarginal, immersed, apices emergent, papilliform, concolorous with thallus or whitish, ostiole pale tan to whitish.

Anatomy. *Thallus* (25-)30-50(-60) μm thick, *cortical cells* ±spherical in section, 5-10(-12) μm diameter, becoming larger towards apothecia, medulla of ±loosely interwoven hyphae, 2-3 μm diameter, with a few ±anticlinally oriented hyphae running from cortex to cortex; *photobiont cells* ±spherical, 5-7 μm diameter, discrete or in chains of 3-7. *Apothecia* (250-)300-350(-360) μm thick; *thalline exciple* basal part (50-)55-100(-120) μm thick, marginal part (50-)60-130(-140) μm thick, *cortex* with paraplectenchymatous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Figures 4-7. Transverse vertical sections of apothecia showing basal and marginal parts of exciples. 4-5: *L. faciifictum* (holotype); 4, basal part and 5, marginal part. 6-7: *L. poliophaeum* (holotype); 6, basal part and 7, marginal part; h = hymenium, pe = proper exciple, sh = subhymenium, st = supporting tissue, tc = thalline excipular cortex, tm = thalline excipular medulla. Scale lines = 50 µm.

supporting tissue, basal part 60-100 µm thick, cells anticlinally elongated, 15-25 x 5-8 µm, marginal part 30-70 µm thick, cells mostly isodiametrical, 7-13 µm diameter; *medulla* as in thallus, but with radiating hyphae from proper exciple to cortex; *proper exciple* of periclinal hyphae, basal part often somewhat interwoven and sometimes obscure, (10-)15-35(-40) µm thick, marginal part becoming ±subparaplectenchymatous at the top and merging into incurved cortex of thalline exciple, (5-)12-20(-25) µm thick; *subhymenium* of densely interwoven hyphae with a general periclinal orientation, sometimes difficult to distinguish from proper exciple, yellowish, (20-)25-60(-80) µm thick; *hymenium* hyaline with pale brownish epihymenium, (100-)125-190(-200) µm thick; *paraphyses* to 2-3(-4) µm diameter, apices not or scarcely swollen; *asci* cylindrico-clavulate, 125-180 µm long; *spores* 6-8, mono- to irregularly distichous, ellipsoid to narrow-ellipsoid with obtuse apices, 17-25 x 6-10 µm, submuriform, with 3-4 lateral septa and 0-1 longitudinal septum; *pycnidia* spherical or depressed-spherical, 60-100 µm diameter; *conidia* bacilliform or with slightly swollen apices, 2-3 x c.1 µm.

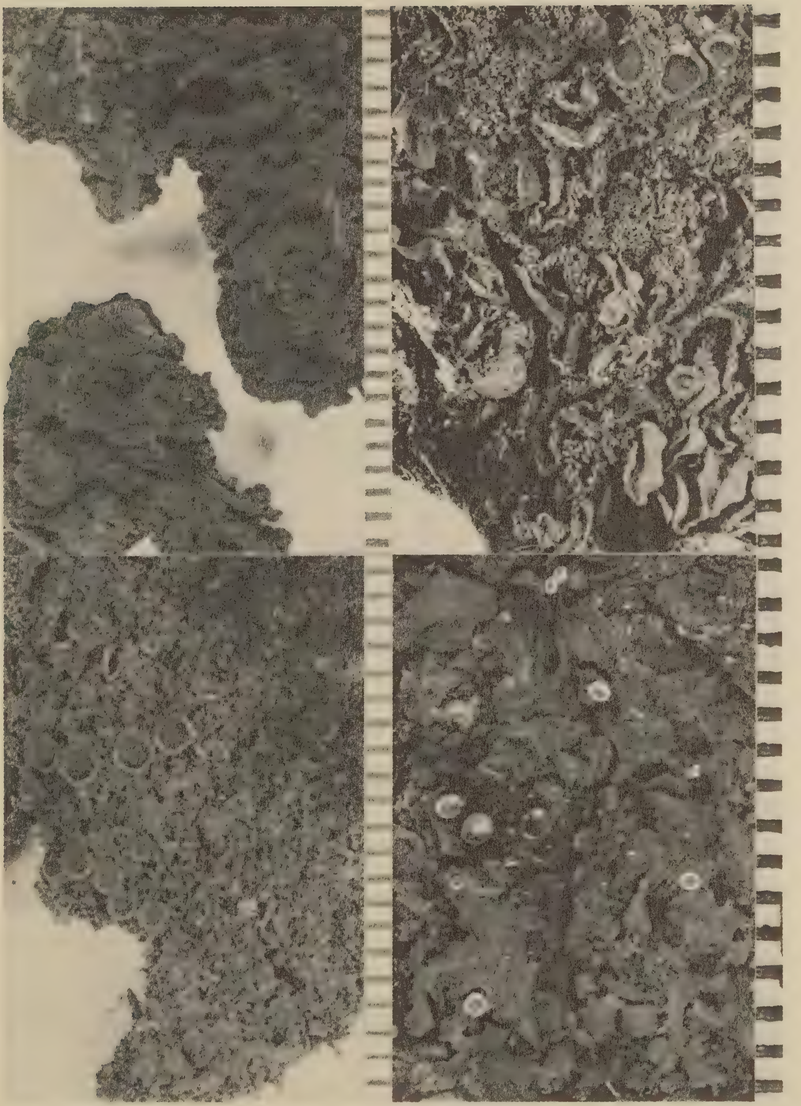
Specimens examined:
AUSTRALIA. QUEENSLAND. On rocks, in rainforest beside rocky stream, Lannercost State Forest, Ashton Creek, Wallaman Falls Road, 28 km W of Ingham, 18°38'S 145°53'E, 300m, J.A.E. 15618 & H.S., 19.vi.1984; on base of tree in gully dominated by *Ficus* and small trees, slopes of Mt. Fox, 43 km SW of Ingham, 18°51'S 145°42'E, 780m, J.A.E. 20337 & H.S., 19.vi.1986; on dead log in disturbed rainforest, Ingham-Kangaroo Hills Road, 30 km WSW of Ingham, 18°46'S 145°54'E, 200m, J.A.E. 20417 & H.S., 19.vi.1986; rock at roadside, tall eucalypt forest, Mt. Glorious, c. 2 km west of Maiala picnic area, [27°18'S 152°45'E], 800m, R.W.R. 2569, 30.v.1983; on vine stem, gully creek bank, *Eucalyptus grandis-Syncarpia glomulifera* association with rainforest understorey (*Archontophoenix cunninghamiana* and *Livistonia australis*), Forest Glen, 8 km SE of Nambour along Bruce Highway, 26°41'S 153°00'E, D.V. 5215, 25.i.1983; on vine stems, broad coastal gully, *Euroschinus falcatus-Podocarpus elatus* rainforest, Noosa Heads, 26°23'S 153°07'E, D.V. 5222, 25.i.1983; on flaky-barked rainforest tree, slope above beach, E aspect, Bingil Bay, 17°51'S 146°06'E, D.V. 5327, 31.i.1983.

Jørgensen (1977: 13) discussed a Tristan da Cunha specimen with "flattened lobule-like" isidia which he placed under *Leptogium denticulatum* auct. non Nyl. and stressed the difficulties of delimitting taxa in the *L. cyanescens* (Rabenh.) Körber group. He considered the Tristan specimens distinctive and belonging to a taxon which is the isidiate counterpart of *L. moluccanum* (Pers.) Vainio. Jørgensen (loc. cit.) also discussed the complicated nomenclatural state of that taxon and suggested *Leptogium propaguliferum* Vainio and *Leptogium leptophyllinum* (Meyen et Flotow) Vainio as names which could possibly be relevent to it. The former of these two taxa has an extant holotype but that of the latter apparently is lost. Vainio (1920: 40), however, cites *L. leptophyllinum* in a diagnosis at the end of his protologue of *L. propaguliferum*, viz.: "*L. leptophyllinum* (Mey. et Flot.) Vain. (*L. denticulatum* Nyl.) thallo haud isidio et margine apotheciorum distinctius denticulato ab ea distinguitur."

L. poliophaeum, with its small, thin, dark lead-grey thallus, appressed habit, and small apothecia differs markedly from the type of *L. propaguliferum*. The latter species has a palish blue-grey and strongly wrinkled thallus which is larger, thicker and ±subpulvinate; its lobes are also plicato-undulate and larger and it has larger apothecia.

The Australian species differs from *L. moluccanum*, not only by its isidia but also by other characters, viz.: its appressed habit, smaller dark grey thallus with smaller lobes, its apothecial proper exciple formed of usually distinct periclinal hyphae, (figs. 6, 7) and its spores which have predominently obtuse apices.

Several sterile specimens have been collected from Australia and New Zealand which possibly are close to the Tristan da Cunha and Brazilian specimens (eg. Malme 1925: 23-4) and have the bluish thin thallus referred to by Jørgensen (1977: 13). *L. poliophaeum* differs from all of these by its dark grey, smaller, appressed thallus and its smaller lobes.



Figures 8-11. New species of *Leptogium* , habit: 8, *L. enkarodes* (holotype); 9, *L. faciifictum* (holotype); 10, *L. pellobatum* (holotype); 11, *L. poliophaeum* (holotype). Scale in mm.

The epithet *poliophaeum* is from the Greek polios (πολιοσ), grey, with phaeos (φαιοσ), dark; referring to the usually dark grey colour of this species.

Leptogium rogersii Verdon sp. nov. Figures 12, 14, 15 & 17.

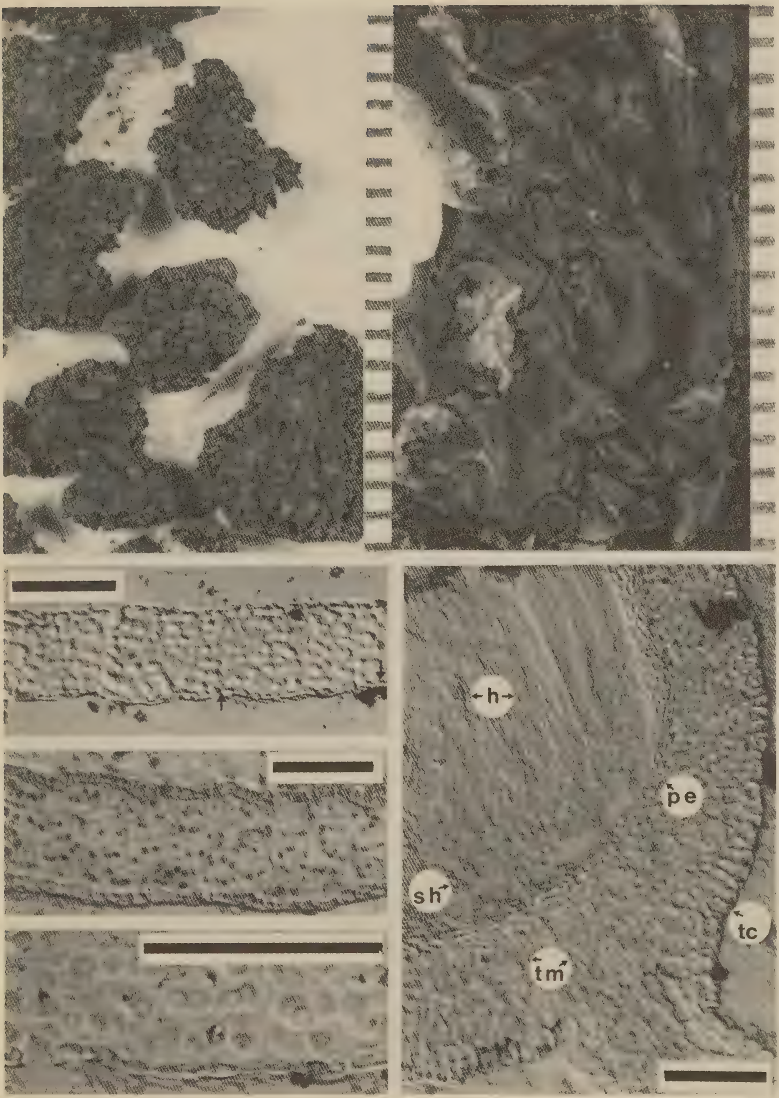
Hoc *L. tasmanico* et *L. pectini* strictim simile sed ab eis speciebus duobus, sporis maturis valde muriformibus cum septis lateralibus 4-6 et septis longitudinalibus 1-3, differt; etiam ab specie prima cortice infero tenuiore cum cellulis compressis, 2-4 µm profundis, lobis parvioribus et tenuioribus, rhizinis inconspicuis, apotheciis parvioribus et ab specie secunda lobulis subteretibus absentibus, apotheciis cum marginibus thallinis tenuibus sed persistentibus in maturitate, discis luteolis, non recurvis in maturitate differt.

Type. Australia. New South Wales. On earth bank, Blue Mountains, c. 2 km WSW of Mt. Wilson, c. 33°31'S 150°22'E, 950m, leg. R. W. Rogers [sine num.] (D. Verdon 5655), 8.v.1988; holotype, MEL.

Thallus terricolous, foliose or ±subsquamulose, irregularly lobate, c.1-3 cm wide; *lobes* rotund to narrow-rotund, 0.3-1.5 mm wide, concave to ±plane, mostly appressed; *margins* ±ascending, slightly undulate, entire or with 1 or 2 isolated orbicular lobules here and there; *upper surface* sordid grey, smooth or a little roughened, matt, wrinkles and isidia absent; *lower surface* similar and concolorous or paler, attached to substrate by inconspicuous bundles of rhizines. *Apothecia* laminal, sessile to broadly adnate and attached to the thallus by hairs, 0.5-1.3 mm diameter; *thalline margin* moderately thin to very thin at maturity, concolorous with thallus or paler; *disc* concave to plane at maturity, very pale yellow; *pycnidia* not seen.

Anatomy. *Thallus* 35-80 µm thick; *upper cortex* cells not flattened in section, irregularly broadly oval to spherical in section, 8-13 µm diameter or 8-12 x 10-15 µm; *lower cortex* thin, cells compressed, oblong in section, 2-4 x 6-8 µm, but larger and less flattened near apothecia; *medulla* of loosely interwoven hyphae 2-3 µm diameter, with many anticlinal hyphae from cortex to cortex; *photobiont cells* ±spherical, 4-5 µm diameter, discrete and scattered to densely clustered or in chains of 3-7. *Apothecia* 200-300 µm thick; *thalline exciple* 50-80 µm thick; *medulla* similar to that of thallus, with few radiating hyphae; *photobiont* as in thallus; *cortex* single-celled or here and there with paraplectenchymatous supporting tissue of variable thickness (26-75 µm), cells ±spherical in section, 5-13 µm diameter; *proper exciple* of distinct periclinal hyphae throughout, 5-7 µm thick, sometimes with a few enlarged cells in centre and in upper marginal part; *subhymenium* pale yellowish, of densely interwoven hyphae 17-100 µm thick; *hymenium* hyaline, 175-200 µm thick with yellowish epihymenium; *paraphyses* to c. 2 µm diameter, apices not or slightly swollen and 2.5-3 µm diameter; *asci* clavulato-cylindrical, 120-150 µm long; *spores* 6-8, mono- to irregularly distichous, ellipsoid with obtuse apices, muriform when mature, with 4-6 lateral septa and 1-3 longitudinal septa, 22-34 x 9-13 µm.

This distinctive species is known only from the type specimen. Its small sordid thallus and compressed lower cortex cells (figs. 14 & 16) seem to place it near to the section Collemodium (Nyl.) Zahlbr. Its upper cortex cells, however, are not compressed and it has a rather thin thallus. The thallus of *L. rogersii* is somewhat similar to that of *L. pecten* and the lower cortex cells of the latter species are sometimes smaller than those of the upper cortex, but they are not consistently compressed as in the former species (fig. 15). *L. rogersii* could also be mistaken for a small specimen of *L. tasmanicum* because its apothecia are adnate and attached to the thallus by hairs as in that species, but its thallus and apothecia are both much smaller. The spores of all three species are also similar in having obtuse apices, often three lateral septa and, variably, one longitudinal septum when immature. In *L. rogersii*, however, the spores are strongly muriform at maturity while those of *L. pecten* and *L. tasmanicum* are submuriform. The apothecia of *L. pecten* vary in size from (1.3-)1.5-2 mm diameter and some specimens of that species



Figures 12-13. Habit: 12, *L. rogersii* (holotype); 13, *L. streimannii* (holotype). Scale in mm. 14-17. Comparative transverse vertical sections: 14, *L. rogersii* thallus (holotype); 15, *L. pecten* thallus (lectotype); 16, *L. rogersii* thallus (holotype); 17, *L. rogersii* apothecium (holotype); h = hymenium, pe = proper exciple, sh = subhymenium, st = supporting tissue, tc = thalline excipular cortex, tm = thalline excipular medulla. Scale line = 50 µm.

may be confused with *L. rogersii*, but *L. pecten* is not terricolous and *L. rogersii* is devoid of narrow-linear lobules.

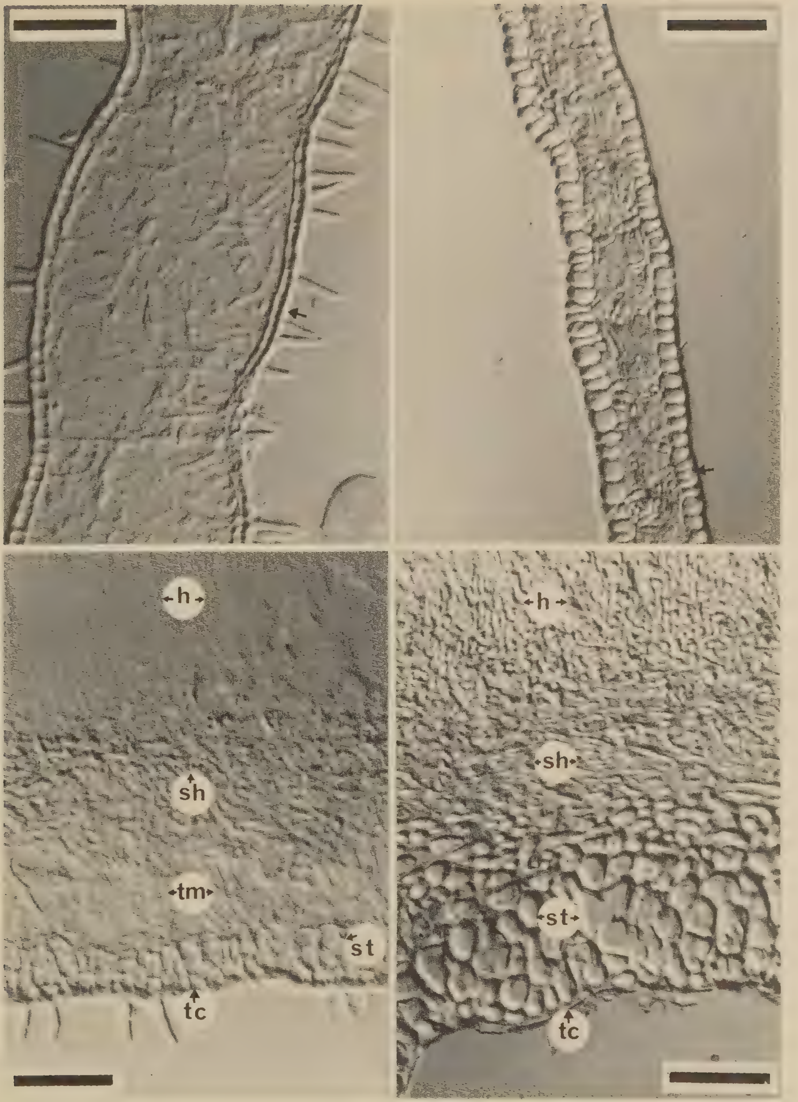
The species is named after Dr R. W. Rogers of Queensland University, who collected the type specimen and who has contributed much to modern Australian lichenology.

Leptogium streimannii Verdon sp. nov. Figures 13, 19 & 21.

Hoc quoad thallum bruneum et discum apotheciorum nigrum *L. australi* Müll. Arg. simile sed ab eo thallo toto glabro, nitente, tenuiore (40-70 µm), cortice excipuli thallini cum textura fulcrante paraplectenchymata multo crassiore (150-200 µm) et excipulo omnino complente e cortice ad subhymenium, sporis latioribus differt.
Type. Papua New Guinea. Eastern Highlands Province. On shrub leaf, disturbed montane forest on ridge, *Castanopsis* dominated, track to Mt. Michael, 5 km SW of Lufa, 6°21'S 145°17'E, 2000m, H. Streimann 18499, 12 Apr.1982; holotype, CBG.

Thallus corticolous, foliicolous, lignicolous or muscicolous, foliose, undulate or here and there plico-undulate, regularly or irregularly lobate, 2-6(-8) cm wide; *lobes* rotund to oblong or sometimes elongate, undulate to plicato-undulate, 2-6(-8) mm broad; *margins* entire to lobulate with rotund to oblong lobules, sometimes lacerate; *upper surface* smooth to roughened, ±purplish brown, glabrous and often polished, isidia absent; *lower surface* similar and concolorous or a little paler, loosely attached to substrate by direct contact or inconspicuous rhizines. *Apothecia* laminal, 1.5-2(-2.5) mm diameter, usually stipitate, stipe at maturity to 1 mm long and half as wide as apothecia or rarely more; *thalline margin* thickish and finely nodulose when young, becoming thin and ±smooth at maturity, brown to pale purplish-brown; *disc* concave to flat, black, or very deep brown when wet; *pycnidia* submarginal, immersed, apex emergent, papilliform, concolorous with thallus, orifice slightly darker.
Anatomy. *Thallus* (30-)40-70(-80) µm thick; *cortical cells* spherical to angular-spherical in section, 8-13 µm diameter; *medulla* of loosely interwoven hyphae 2-4 µm diameter, mostly with periclinal orientation but with some anticlinal hyphae here and there, diffuse purplish-brown pigment present; *photobiont cells* ±spherical, 2-5 µm diameter, discrete to clustered or in chains of 3-6. *Apothecium* 400-500(-550) µm thick; *thalline exciple* basal part 150-200(-250) µm thick; *cortex* with paraplectenchymatous supporting tissue filling exciple, inner 2-3 rows of cells spherical, 20-30 µm diameter, the rest anticlinally oriented, oblong to narrow-oblong, 20-30 x 5-13 µm, marginal part 100-140 µm thick, cells somewhat smaller; *proper exciple* basal part obscure, marginal part of periclinal hyphae or with subparaplectenchymatous tissue in upper portion; *subhymenium* with ±dense purplish-brown pigment, 100-150(-200) µm thick, of densely interwoven hyphae with somewhat thick-walled cells; *hymenium* 160-200(-250) µm thick, with diffuse purplish-brown pigment and dark brown to blackish epihymenium; *paraphyses* 2-3(-4) µm diameter, apices slightly swollen, 3-5 µm diameter; *asci* cylindrico-clavulate, 150-190(-200) µm long; *spores* 6-8, mono- to distichous, 30-40(-45) x 13-17 µm, ellipsoid with acuminate apices, submuriform to muriform with 5-6 lateral and 0-1(-2) longitudinal septa; *pycnidia* depressed-spherical, 200-300 µm diameter; *conidia* bacilliform, sometimes with swollen apices, 2-5 x c.1 µm.

Specimens examined:
PAPUA NEW GUINEA. CENTRAL PROVINCE. On *Wendlandia* in regrowth forest, Aseki-Bulolo road, 1.5 km NW of Aseki, 7°21'S 146°11'E, 1580m, J.A.E 12216 & M. Toia, on mossy trunk, [loc. cit.], J.A.E. 12238 & M. Toia, 5.xii.1982.
EASTERN HIGHLANDS PROVINCE. On *Castanopsis* in *Castanopsis-Lithocarpus* forest, Pusarasa Village, 2 km NNW of Okapa, 6°30'S 145°36'E, 1720m, J.A.E. 12554 & H.S.; on vine, [loc. cit.] J.A.E. 12601 & H.S., 9.xii.1982; on a shrub, old disturbed area in montane forest, Gahavisaku Provincial Park above Nagamiza Village, 5 km N of Goroka, 6°01'S 145°25'E, 1800m, H.S. 19453, 8.iv.1982.



Figures 18-21. Comparative transverse vertical sections: 18, *L. australe* thallus (H. Roivainen 13/11.1929, H); 19, *L. streimannii* thallus (holotype); 20, *L. australe* apothecium central part (H. Roivainen 13/11.1929, H); 21, *L. streimannii* apothecium, central part (holotype); h = hymenium, pe = proper exciple, sh = subhymenium, st = supporting tissue, tc = thalline excipular cortex, tm = thalline excipular medulla. Scale lines = 50 µm.

SOUTHERN HIGHLANDS PROVINCE. On leaves in *Nothofagus* forest, Tari Gap, 19 km SE of Tari, 5°57'S 143°05'E, 2200m, J.A.E. 13310 & H.S., 17.xii.1982.

Leptogium streimannii appears to be genuinely rare as it has been found at just four locations, all at montane or upper montane altitudes, even though collecting trips in Papua New Guinea so far have covered a fairly wide range of habitats at various altitudes.

This species is interesting because of its brown thallus and black apothecial disc, characteristics previously known only in *L. australe* (J. D. Hook. et Taylor) Müll. Arg. It can be distinguished from that species by its completely glabrous and much thinner thallus (fig. 19) which is usually glossy. Other distinguishing characters are its broader spores and the structure of its apothecial thalline exciple, which is filled by paraplectenchymatous supporting tissue (fig. 21) from cortex to subhymenium. Interesting also is the brown to purplish-brown diffuse pigment within the thallus and the apothecium, where it is most dense in the subhymenium. This pigment is insoluble in acetone and weakly soluble in water when heated. No such pigment was seen in the three specimens of *L. australe* examined but whether the pigment will deteriorate over time in dried herbarium specimens is not known.

This species is named after the collector of the type specimen, Mr H. Streimann, Curator of Cryptogams at the Herbarium (CBG) of the Australian National Botanic Gardens in Canberra, who has made numerous valuable collections in both Papua New Guinea and Australia.

NEW RECORDS

Leptogium austroamericanum (Malme) Dodge

Corticolous or saxicolous in *Eucalyptus* moist forests or woodlands, rainforests or mangroves in coastal areas, or on subcoastal mountains from south to north Queensland. The type specimen of this species is small and subpulvinate with cylindrical and squamuliform isidia. Its apothecia are small with more or less smooth, non-isidiate thalline margins and its proper exciple is euparaplectenchymatous but weakens near the centre of the basal part. A few of the south Queensland specimens match it reasonably well but in more northerly specimens the habit is more spreading, the isidia are all cylindrical and the apothecia have periclinally wrinkled margins. In addition the basal part of the apothecial proper exciple in these northern specimens is stronger and thicker.

This variation, however, agrees with the present concepts of *L. austroamericanum* which is recorded here for the first time from Australia.

Specimens examined:

AUSTRALIA. QUEENSLAND. On roadside trees, 1.5 km N of Best of All Lookout, Wunburra Range, 805m, J.A.E. 2538, 20.viii.1976; on rocks in rainforest beside rocky stream, Lannercost State Forest, Ashton Creek, Wallaman Falls Road, 28 km W of Ingham, 18°38'S 145°53'E, 300m, J.A.E. 15622 & H.S., 19.vi.1984; on remnant trees along the roadside, Tully Falls Road, 8 km SE of Ravenshoe, 17°40'S 145°31'E, 940m, J.A.E. 16778 & H.S., 29.vi.1984; on base of *Eucalyptus*, along the track in poor rainforest, O'Keefe Creek, Big Tableland, 26 km S of Cooktown, 15°43'S 145°15'E, 370m, J.A.E. 17323 & H.S., 4.vii.1984; on mangroves in tidal flats, Newell Beach, 5 km NE of Mossman, 16°26'S 145°24'E, 1m, J.A.E. 17464 & H.S., 6.vii.1984; on canopy of *Argyrodendron* in rainforest dominated by *Syzygium* and *Argyrodendron trifoliatum*, Crediton State Forest, 20 km SSW of Finch Hatton, 21°19'S 148°33'E, 840m, J.A.E. 21033 & H.S., 1.vii.1986; on exposed roots, in deep seasonal creek, surrounded by *Ficus*, *Drypetes*, *Diospyros*, between Spring and Charleys Creeks, 23 km WSW of Proserpine, 20°28'S 148°22'E, 120m, J.A.E. 21143 & H.S., 2.vii.1986; on rocks in creek bank, Neranwood, R.W.R. 2537, 14.i.1982; granite boulders in *Eucalyptus* forest, Settlement Road, Keperra [Brisbane], [27°25'S 152°57'E], 200m, R.W.R. 2637, 17.vi.1983; tree trunk in *Araucaria* forest, Noosa National Park, [26°23'S 153°07'E], near Laguna Lookout, c. 100m, R.W.R. 7740, 7741, 28.ix.1985; Beechmont, c. 28°05'S 153°12'E, G.N.S. [sine num. vel die]; on fallen branch, logged rainforest, Hugh Nelson Range, Crater State Forest, 19 km S of Atherton, 17°26'S 145°29'E, 1000m, H.S. 27185, 2.iii.1983; on trunk of large *Eucalyptus*, *Eucalyptus grandis* dominated grasslands area on ridge, Hugh Nelson Range, 15 km S of Atherton, 17°25'S 145°26'E, 1090m, H.S. 29516, 25.vi.1984.

Leptogium biloculare F. Wilson

This species with its small bilocular spores is unique in the genus *Leptogium* and until now was known only from south-eastern Australia. It is sparsely distributed in low montane to subalpine areas of Victoria and Tasmania, and three collections are known so far from the Southern Tablelands of New South Wales. Its preferred habitats on the Australian mainland are either moist *Eucalyptus* forests, on the bases of *Eucalyptus viminalis* or on stems and branches of shrubs and trees in the mesophyll understorey. In Tasmania on the other hand it has been found on a wider range of shrubs and trees, including *Nothofagus*. Its occurrence on the mainland is frustratingly sporadic, even in seemingly optimum habitats, but in similar Tasmanian habitats it seems to occur a little more frequently, due possibly to the more moist climate of the island state. Even in Tasmania, however, specimens from most locations are recorded as uncommon or rare.

As a cool temperate species its occurrence in New Zealand is not unexpected and is recorded here for the first time.

Specimen examined:
NEW ZEALAND. SOUTH ISLAND. Beech forest along road, NW Otago, 20.7 km N of Makaroa on Haast Road, ca. 320m, M.E.H. 66264, 31.i.1984.

Leptogium bullatulum Müll. Arg.

F. M. Bailey, Government Botanist in the state of Queensland during the late nineteenth century, collected the type specimen of this species from Bellenden Ker in north Queensland. Specimens collected more recently in Queensland were at first considered to be different from the small extant piece of the type specimen. Following study of Papua New Guinea specimens, however, it is now considered that all specimens including the type are members of the same variable species.

The extant part of the type specimen is sterile although Müller (1891: 47) described apothecia. He also described the lobe margins as ".. integrae et hinc inde crebre ciliatae, .." (Müller l.c.); Müller may possibly have observed fine isidia on the lobe margins, but those of the extant type specimen have neither cilia nor isidia. It appears that Müller's protologue may have been based mainly on the missing part of Bailey's collection, which possibly contained two taxa. However, I have been unable to locate this missing part, so the emended description below is based on the protologue in part, and the extant type specimen, together with the more recent specimens.

Descriptionem emendatam:

Thallus corticolous, foliose, spreading or subpulvinate to pulvinate, irregular, undulate to plicato-undulate, 1-5(-6) cm wide; *lobes* orbicular to rotund, concave or undulate to ± plicato-undulate, ascending to erect or spreading, with ascending margins, (1.5-)2-4(-5) mm diameter; *margins* entire or rarely with a few lobules usually where damaged, undulate to plicato-undulate; *upper surface* lead-grey to dark lead-grey, often finely and closely wrinkled, isidia absent, *wrinkles* anastomosing, with an intertextoid appearance, clearly observed at x15, often appearing granuloid at x10, sometimes more open to sparse or absent in some parts, (in type specimen and some specimens from PNG); *lower surface* similar and concolorous or paler, often with coarser wrinkles, attached to substrate by direct contact or inconspicuous rhizines. *Apothecia* laminal to ±submarginal, arising in small bullae, partially and obliquely immersed or ±adnate at maturity, 2-3(-4) mm diameter; *thalline margin* with small, ±concentric ridges and nodules or rarely with thick rudimentary lobules, prominent above disc when young, less so when mature; *disc* reddish-brown to brown or dark brown, concave to plane at maturity; *pycnidia* submarginal, immersed, apex emergent, papilliform, concolorous with thallus or pale tan, orifice tan to brown.

Anatomy. *Thallus* (70-)80-150(-160) µm thick, *cortex cells* irregularly spherical, (7-) 9-12 µm diameter; *medulla* of somewhat loosely interwoven hyphae, 2-4 µm diameter, with a strongly periclinal orientation in mid-thallus, with some anticlinal hyphae from cortex to cortex; *photobiont cells* ±spherical, 3-5 µm diameter, discrete to clustered or in chains of 3-7. *Apothecia* 250-350 µm thick; *thalline exciple* (70-)100-220(-250) µm thick, *cortex* with paraplectenchymatous supporting tissue, basal part 50-100(-130) µm thick, inner cells spherical (10-)12-17(-18) µm diameter, the rest oblong to narrow-oblong, (7-)10-18(-20) x 4-10 µm, marginal part 10-70 µm thick, cells similar; *medulla* as in thallus; *photobiont cells* very sparse; *proper exciple* basal part poorly formed of periclinal hyphae or absent; marginal part of subparaplectenchymatous tissue, paraplectenchymatous near top; *subhymenium* (50-)60-100(-120) µm thick, cream to yellowish, of densely interwoven hyphae 2-3 µm diameter, with a general periclinal orientation; *hymenium* hyaline, without definable epihymenium, *paraphyses* 2-3 µm diameter, not or scarcely swollen at apices; *asci* cylindrico-clavulate, 90-125(-150) µm long; *spores* 6-8, mono- to irregularly distichous, ellipsoid to broadly ellipsoid with predominantly subacute to acute, slightly acuminate or rarely obtuse apices (this variation usually found within one apothecium), muriform at maturity with 4-6(-7) lateral and 1-2 longitudinal septa, (26-)30-43(-46) x 12-16 µm; *pycnidia* ±depressed-globular, c. 200 µm diameter; *conidia* bacilliform, 2-3 x c. 1µm.

Specimens examined:

PAPUA NEW GUINEA. EASTERN HIGHLANDS PROVINCE. On vine, in remnant *Castanopsis* forest, Waiopa, Aiyura-Omaura road, 13 km SE of Lainantu, 6°22'S 145°58'E, 1450m, J.A.E. 12401 & H.S., 8.xii.1982.

ENGA PROVINCE. On a shrub, advanced regrowth beside creek, Urticaceae dominated, Mape Creek, Mount Hagen-Wapenamanda Road, 17 km SE of Wapenamanda, 5°46'S 143°57'E, 2500m, H.S. 21553, 29 vi.1982 (dup. LAE).

MILNE BAY PROVINCE. On *Cryptocarya* stem and branches, forest dominated by *Syzygium, Endospermum, Calophyllum, Dysoxylum* and *Pometia,* Woodlark Island, Kaurai logging area, 9 km N of Kulumadau, 9°01'S 152°43'E, 100m, R. Kumei 74, 9.x.1984 (CBG).

MOROBE PROVINCE. On *Araucaria hunsteinii* in lower montane forest, Heads Hump Logging Area, 4 km ESE of Bulolo, 7°13'S 146°41'E, 780m, J.A.E. 11917 & H.S., 3.xii.1982; on dead twigs in disturbed montane forest, Aseki-Menyama road, 6 km NW of Aseki, 7°19'S 146°09'E, 1950m, J.A.E. 12114 & M. Toia, 5.ii.1982; crown of large tree, alongside small gully at side of *Castanopsis*-Dipterocarpaceae dominated forest, Herzog Mountains, 15 km WSW of Lae, 6°45'S 140°51'E, 760m, H.S. 11083 & T. Umba, 13.i.1981; on upper *Araucaria cunninghamii* branches, *Castanopsis-Galbulimima* dominated forest on gentle slope, logging area, 15 km W of Bulolo, 7°18'S 146°45'E, 1500m, H.S. 13124 & A. Bellamy, 27.i.1981; on old tree trunk, disturbed lower montane forest on north facing slope, Middle Creek-Watut River Divide, 8 km NW of Bulolo, 7°09'S 146°35'E, 950m, H.S. 14325, 27.i.1981; upper branches of large *Calophyllum soulattri, Castanopsis-Lithocarpus* forest on gentle SW slope, Nauti Logging Area, Upper Watut River, 10 km SW of Bulolo, 7°16'S 146°36'E, 1400m, H.S. 17192, 3.iii.1982.

SOUTHERN HIGHLANDS PROVINCE. On *Nothofagus* crown in *Nothofagus-Podocarpus* forest, Andawe River, Lama sawmill logging area, 6 km SE of Ialibu, 6°20'S 144°01'E, 1840m, J.A.E. 12736 & H.S., 11.ix.1982; on sapling, [loc. cit.], J.A.E. 12751 & H.S.

AUSTRALIA. QUEENSLAND. On bark, Bellenden-Ker, F. M. Bailey 555, 1889 [holotype-BRI]; on canopy twigs in rainforest along stream, Lannercost State Forest, Blue Water Creek, Old Mill Road, 39 km WSW of Ingham, 18°45'S 145°48'E, 600m, J.A.E. 15493 & H.S., 19.vi.1984; on *Timonius*, in *Eucalyptus* woodland along rainforest margin, Kirrima State Forest, Kirrima Road, 32 km WNW of Cardwell, 18°11'S 145°44'E, 580m, J.A.E. 15777 & H.S., 20.vi.1984; on base of *Eucalyptus grandis* in *E. grandis* woodland, Hugh Nelson Range, along Plath Road, 15 km S of Atherton, 17°25'S 145°26'E, 1080m, J.A.E. 16377 & H.S., 25.vi.1984; on remnant trees along roadside, along Tully Falls Road, 8 km SE of Ravenshoe, 17°40'S 145°31'E, 940m, J.A.E. 16781, 16788 & H.S., 29.vi.1984; on vine, remnant trees along roadside, 1 km S of Maalan, 11 km E of Ravenshoe, 17°36'S 145°38'E, 980m, J.A.E. 17110 & H.S., 2.vii.1984; on sapling, along the margin of stunted rainforest, Big Tableland, 26 km S of Cooktown, 15°43'S 145°17'E, 610m, J.A.E. 17287 & H.S., 4.vi 1984; on saplings, along the rainforest margin, Kirrima State Forest, Cardwell Range, Dunn Creek, 23 km WNW of Cardwell, 18°12'S 145°49'E, 730m, J.A.E. 17633 & H.S., 8.vii.1984; on tree trunk in lowland rainforest, Conway State Forest, 18 km E of Proserpine, 20°21'S 148°45'E, 80m, J.A.E. 20180 & H.S., 28.vi.1986; on basalt rocks in poor, scrubby forest on rocky hillside, Charleys Creek, 18 km NNE of Proserpine, 19°51'S 148°39'E, 50m, J.A.E. 20999 & H.S, 30.vi.1986; on trees in opened rainforest, between Millaa Millaa and Ravenshoe, D. McVean 6392A, xi.1963 (CBG); crown of medium-sized *Eniandra*, logged rainforest on flats, Boonjie State Forest, 22 km SE of Yungaburra, 17°24'S 145°45'E, 600m, H.S. 27587, 4.iii.1983; on fallen rotting tree branch and on crown of large fallen *Polyscias,* rainforest on side of ridge, Koombooloomba Dam road, 23 km SE of Ravenshoe, 17°49'S 145°33'E, 780m, H.S. 28904, 23.vi.1984; in crown of medium-sized *Litsea,* rainforest on side of ridge, Main Coast Range, 19 km WNW of Mount Molloy, 16°31'S 145°16'E, 1200m, H.S. 30257, 30 vi.1984; on vine, remnant shrubs and treelets between road and paddock, Maalan, 11 km E of Ravenshoe, 17°36'S 145°35'E, 980m, H.S. 30582, 2.vii.1984; on tree trunk, lowland rainforest on gentle slope, Conway State Forest, 18 km ENE of Proserpine, 20°21'S 148°45'E, 180m, H.S. 37358, 28.vi.1986; remnants of rainforest, old logging area, 26.6 km on Mulgrave River Forestry Road SW of Gordonvale, [c. 17°07'S 145°47'E], 1-200m, M.E.H. 69122, 22.vii.1983.

Leptogium coralloideum (Meyen et Flotow) Vainio

This corticolous or sometimes saxicolous species is widespread in south-eastern Australia and New Zealand, and a few sterile specimens which possibly belong here have been collected from northern New South Wales and southern Queensland. A single sterile specimen that also seems to belong here has been collected fom Papua New Guinea. It grows in a wide range of habitats such as riparian thickets, moist to moderately moist *Eucalyptus* forests or woodlands, or in pastureland, often on introduced trees. However, in fertile Australian collections all but three of the specimens have been found in moist limestone areas where they were corticolous or saxicolous. Two of the three exceptions were corticolous in a coastal *Leptospermum* swamp and the other was collected in an inland area of volcanic rocks. The species also has wide altitudinal preferences, in Australia ranging from sea level to 1300 metres.

In the past *L. coralloideum* has been confused with *L. brebissonii* Mont.(e.g. Weber & Wetmore 1972: 55) as some forms are superficially similar. It differs from this species, however, by its muriform ellipsoid spores and the central part of its proper exciple in which the cells are all spherical or slightly angular-spherical. In the latter species on the other hand, the spores are acicular and lack longitudinal septa, and the cells in the major part of its proper exciple are oblong to narrow-oblong and anticlinally oriented. Another species that may be confused with *L. coralloideum* in the sterile state is *L. isidiosellum* (Ridd.) Sierk. The latter has similar wrinkles but differs from *L. coralloideum* by its smaller lobes, smaller sessile to adnate apothecia and much thinner proper exciple with smaller cells.

It is interesting that *L. coralloideum* recently has been recorded for the first time from Europe (Krog 1988). The species also is recorded here for the first time from Papua New Guinea, Australia and New Zealand.

Specimens examined:
PAPUA NEW GUINEA. MOROBE PROVINCE. On *Antidesma* stem, grasslands on gentle slope with some regrowth species, Tauri River, Menyama, 7°07'S 145°59'E, 1200m, H.S. 18926, 29.iv.1982.
AUSTRALIA. AUSTRALIAN CAPITAL TERRITORY. On *Casuarina cunninghamiana* in open forest, along Paddy's River near Murray's Corner, [c. 35°26'S 148°58'E], 550m, J.A.E. 5929, 29.iii.1979; on *Leptospermum* in thicket, Cotter Dam, 20 km W of Canberra, [35°19'S 148°56'E], 590m, J.A.E. 11479 & S. A. Elix, 4.xii.1983; on large granite outcrop with easterly aspect, dry sclerophyll forest beside stream, Glendale Crossing, Gudgenby River, 44 km SSW of Canberra, 35°44'S 149°00'E, 900m, H.S. 10249, 18.May.1980(dup. H); on shaded *Leptospermum* trunk, *Leptospermum* dominated scrub beside stream in dry sclerophyll forest, Tidbinbilla Nature Reserve, 28 km SW of Canberra, 35°29'S 148°54'E, 850m, H.S. 10646, 16.xi.1980(dup. Nich, H).
NEW SOUTH WALES. On trees in moist forest gully, along Reedy Creek, Marble Arch, 48 km S of Braidwood, [35°44'S 149°42'E], 620m, J.A.E. 4408, 2.iii.1978; on limestone rocks, J.A.E. 4417, 2.iii.1978; on *Callitris columellaris* in *Callitris* forest, 24 km N of Grenfell along the Forbes road, [c. 33°46'S 148°22'E], J.A.E. 4824, 15.vii.1978; on trees along the creek bank, Bungonia Creek below the canyon, 30 km E of Goulburn, [c. 34°43'S 149°56'E], 160m, J.A.E. 4943, 13.ix.1978; on old *Populus,* in pastureland, Countegany-Kybean Road, 36 km ESE of Cooma, 36°19'S 149°30'E, 1000m, J.A.E. 11456 & H.S., 15.xi.1983; on mossy limestone rocks, scattered *Brachychiton* and *Eucalyptus* with dense *Bursaria spinosa* understorey and numerous limestone outcrops, road to Careys Cave, 1 km NNE of Wee Jasper, 35°07'S 148°40'E, 400m, J.A.E. 22741 & H. Mayrhofer, 10.viii.1988; rocky outcrop in eucalypt forest, near White Swamp (road to Boonah Gate), [28°17'S 152°31'E], c. 800m, R.W.R. 7699, 30.iv.1983; on big branches of *Brachychiton,* limestone outcrop in paddock with scattered *Brachychiton* and *Callitris*, Limestone Valley Creek, 9 km NE of Canowindra, 33°36'S 148°41'E, 460m, H.S. 9252, 8.viii.1979(dup. H, US, TNS); on fallen *Casuarina cunninghamiana* branch, *Eucalyptus* and *Casuarina* dominated vegetation on creek flats, Majors Creek, 5 km NW of Araluen, 35°37'S 149°46'E, 220m, H.S. 15405, 8.iv.1981 (dup. NICH, H); on planted poplars, grazed paddock on gentle slope, Countegany-Kybean Rd., 36 km ESE of Cooma, 36°19'S 149°30'E, 1000m, H.S. 28168, 15.xi.1983; on exotic street trees (Elm), Mount Wilson, 23 km NNE of Katoomba, 33°31'S 150°21'E, 980m, H.S. 31538, 1.xi.1984 (dup. H, US); on large *Eucalyptus* trunk, sassafras and treefern dominated southern facing slope, Misty Mountain Forest Road, Currowan State Forest, 23 km NW of Batemans Bay, 35°34'S 149°59'E, 400m, H.S. 37881, 2.xii.1986; on *Bursaria spinosa* branches, moist gully, *Eucalyptus* forest with *Leptospermum* and *Bursaria* creekside community, Brindabella Valley, Diamina Creek, 36 km SW of Canberra, 35°23'S 148°44'E, 620m, D.V. 1550, 4.viii.1975; on *Bedfordia* trunk and branches, montane, SW aspect, *Eucalyptus* forest with *Pomaderris aspera-Bursaria spinosa-Bedfordia salacina* understorey, above caves, 32 km SSW of Braidwood, 6.5 km E of Emu Flat, Moodong Creek, Marble Arch, 35°44'S 149°42'E, 650m, D.V. 3423, 23.ii 1978; on Bryophyta and bark of fallen tree, gradually sloping forest floor, easterly aspect, moist *Eucalyptus fastigata* forest, Big Badja Hill, 47 km NE of Cooma, 36°00'S 149°34'E, 1300m, D.V. 3492, 2.iii.1978; on *Bedfordia salicina* along stream, head of Neringla (Back) Creek, 3 miles NE of The Big Hole near Krawaree, ca. 2500 ft., E of Shoalhaven River, W. A. Weber & D. McVean, 19.iii.1968 (Lichenes Exsiccati 317; distr. by COLO as *Leptogium brebissonii* Mont. in Webb) (HO); Apsley Falls, 12 miles E of Walcha on the Walcha-Wauchope road, [c. 30°59'S 151°33'E], R. Filson 7227, 19.v.1965 (MEL); Nuada Rocks, Warrumbungle Mountains, [c.31°19'S 148°59'E], R. Filson 7875, 4.xi.1965 (MEL); Jenolan Caves, [33°49'S 150°02'E], Rev. F.R.M. Wilson [sine num.], ix.1897 (MEL) [dup. NSW].
VICTORIA. On *Callitris* tree in *Callitris* forest , along the western bank of the Snowy River, just S of the NSW border, [c. 37°34'S 148°18'E], 200m, J.A.E. 5038, 21 ix.1978; on *Callitris* tree in dry sclerophyll forest, Jacobs River Bridge, 20 km S of Ingebyra, [c. 36°40'S 148°30'E], 400m, J.A.E. 5057, 21.ix.1978; Dinah Divide Track,

9 km SE of Club Terrace, 37°36'S 149°00'E, 400m, J.A.E. 21992 and H.S., 30.iii.1988; on *Leptospermum* trunk with *Psoroma leprolomum* and *Catillaria* sp., coastal hills, high river bank, c. 5m above river, *Eucalyptus* closed moist forest with *Acmena smithii-Acacia mearnsii* rainforest understorey and *Leptospermum phylicoides [Kunzea ericoides]* at lighter edges, Gippsland, Waygara State Forest, 25 km SE of Buchan along the Orbost Road, 37°37'S 148°15'E, 200m, D.V. 4278, 22.xi.1978; on tree, Warrnambool, F.R.M. Wilson [sine num.], xi.1885(MEL); McKillops Bridge on the Snowy River, 18 miles E of Wulgulmerang, R. Filson 8324, 7.iii.1966(MEL).
TASMANIA. On paperbark, sheltered, Chain of Lagoons, Freycinet Peninsula, 41°40'S 148°18'E, G.C. Bratt & M.H. Bratt (Bratt Herb. 809), 25.xi.1963(HO); on *Leptospermum*, sheltered marshy thicket, Moulting Lagoon, 42°01S 148°13'E, 6 ft. above high water, G.C. Bratt & M.H. Bratt (Bratt Herb. 1914), 31.i.1965(HO)(dup. AD, MEL); on *Leptospermum* in swampy, sheltered area, Moulting Lagoon at Friendly Beach turn off, 42°00'S 145°15'E, 1m, G.C. Bratt & J.A. Cashin (Bratt Herb. 68/1261), 19.ix.1968(HO); on *Melaleuca ericifolia* in damp, shaded swamp, Tea Tree Grove, Chain of Lagoons River Mouth, 41°40'S 148°18'E, G.C. Bratt & J.A. Cashin (Bratt Herb. 73/729), 8.vii.1973(HO).
NEW ZEALAND. NORTH ISLAND. On cabbage trees in parkland, Turuturu-mokai Pa site, Hawera, Taranaki, J.A.E. 7929, 6.v.1980; on manuka in scrubland, Haruru Falls-Waitangi trail, 30m, J.A.E. 8076, 12.v.1980; on trees in open scrubland, trail to Cathedral Cove, Hahei, Coromandel Peninsula, 15m, J.A. Elix 9981, 9.i.1982; Little Barrier (Hauturu) Island, 36°01'S 175°0'E, B.W. Hayward, viii.1981 (AK); on kanuka, Hen and Chicken Islands, Mauitahi Island, 35°53'S 174°43'E, B.W. Hayward, i.1982 (AK); mixed kanuka forest, off Great Barrier Island, Broken (Pig) Islands, Junction Islands, 36°14'S 175°19'E, B.W. & G.C. Hayward, i.1985 (AK).
SOUTH ISLAND. On bark of mahoe/kanuka/five finger, Marlborough Sounds, Chetwode Islands, Nukuqaiata Island, 40°53'S 174°06'E, B.W. Hayward, iii.1984 (AK); forest along highway, 3.7 km E of Whataroa on Hwy. 6 at Arthurs Creek, ca. 30m, M.E.H. 66155, 2.ii.1984; on rocks, beech-podocarp forest, Waioeka Gorge Scenic Reserve, 11 km SW of Matawai on Hwy. 2, ca. 300m, M.E.H. 66210, 12.ii.1984.

Leptogium corniculatum (Hoffman) Minks

A specimen collected by Dr. J. H. Willis has the distinctive corniculate lobes typical of this species and has similar apothecia. The specimen was found on the sheltered north side of Middle Island, Recherche Archipelago, Western Australia. It differs from northern hemisphere specimens by its broader lobes and larger apothecia but is similar in apothecial anatomy. Thus in the absence of correlating characters these differences cannot be considered significant, and the species is therefore recorded here for the first time from Australia.

Specimens examined:
AUSTRALIA. WESTERN AUSTRALIA. Light humus on the ground in *Melaleuca* groves, northern coast, Middle Island, [c. 34°06'S 123°11'E], J. H. Willis [sine num.], 2.xi.1955 (MEL).
CANARY ISLANDS. Gomera, La Laja, 350-600m, Eilif Dahl [sine num.], 15.i.1973 (ANUC).
JAPAN. Mt. Ryogami, Titibu, Prov. Mususi, leg. S. Kurokawa, 2.xi.1955 (Lich. Jap. Exsicc. 169, Nat. Sc. Mus., Tokyo, as *L. palmatum* f. *fusidosporum* Kurokawa), (ANUC).

Leptogium fallax Müll. Arg.

Confusion can arise in determining some specimens referable to this species, although it is readily recognised by its strongly wrinkled thallus and mature apothecia which are large (to 5mm diameter) and are surrounded by large lobules. At an intermediate stage of development, however, the apothecium usually has no surrounding lobules and the thalline margin is adorned with an attractively crenulate edge. It is then up to 2mm diameter and specimens lacking mature apothecia can be determined mistakenly as a different taxon until the apothecia are recognized as immature. Several such specimens have been collected in Australia.

L. fallax was originally described from Java in Indonesia and recently has been collected from a moderate range of montane habitats in several provinces of Papua New Guinea and in the northern region of Queensland, Australia. It is corticolous and saxicolous in rainforest and woodland areas and is recorded here for the first time from these two countries.

Specimens examined:
PAPUA NEW GUINEA. MOROBE PROVINCE. On *Castanopsis* in mixed *Castanopsis* forest, Nauti Logging Area, 13 km SSW of Bulolo, 7°17'S 146°36'E, 1500m, J.A.E. 11828 & A. Vinas, 3.xii.1982; on *Vaccinium albicans,* advanced regrowth on ridge with young *Lithocarpus*, Heads Hump, 4 km ESE of Bulolo, 7°13'S 146°40'E, 900m, H.S. 17815, 22.iii.1982; head of large *Castanopsis*, *Castanopsis* forest on SW facing slope, Nauti Logging Area, Upper Watut River, 10 km SW of Bulolo, 7°16'S 146°36'E, 1400m, H.S. 17069, 3 iii.1982 (dup. LAE, H).
SOUTHERN HIGHLANDS PROVINCE. Andawe River, Lama Sawmill logging area, 6 km SE of Ilabu, 6°20'S 144°01'E, in *Nothofagus-Podocarpus* forest on *Nothofagus*, 1640m, J.A.E. 12722 & H.S., 11.xii.1982.
AUSTRALIA. QUEENSLAND. On exposed roots of tree in rainforest beside stream, Lannercost State Forest, Ashton Creek, Wallaman Falls Road, 28°38'S 145°53'E, 300m, J.A.E. 15629 & H.S., 19.vi.1984; on granite rocks, in *Eucalyptus* woodland, Gillies Highway, 13 km SW of Gordonvale, 17°09'S 145°43'E, 300m, J.A.E. 16717 & H.S., 28.vi.1984; along roadside on remnant trees, along the Tully Falls Road, 8 km SE of Ravenshoe, 17°40'S 145°31'E, 940m, J.A.E. 16826 & H.S., 29.vi.1984; on base of *Alphitonia* along the margin of stunted rainforest, Big Tableland, 26 km S of Cooktown, 15°43'S 145°17'E, 610m, J.A.E. 17270, 17271 & H.S., 4.vii.1984; on shaded rocks in disturbed rainforest, Ingham-Kangaroo Hills Road, 30 km WSW of Ingham, 18°46'S 145°54'E, 200m, J.A.E. 20418 & H.S., 19.vi.1986; on trunk of large *Eucalyptus*, *E. grandis* dominated grasslands area on a ridge, Hugh Nelson Range, 15 km S of Atherton, 17°25'S 145°26'E, 1090m, H.S. 29519, 25.vi.1984; on large boulder, *Eucalyptus* dominated grasslands on steep boulder-strewn hillside, Gillies Highway, 13 km SW of Gordonvale, 17°09'S 145°43'E, 300m, H.S. 30052, 28.vi.1984; on shaded rock edge of stunted rainforest and grasslands on large exposed rock outcrop, Big Tableland, 26 km S of Cooktown, 15°43'S 145°17'E, 580m, H.S. 30859, 4.vii.1984; open forested area along river, Fresh Water Gorge, outside of city of Cairns, [16°55'S 145°46'E], M.E.H. 69127, 13.vii.1983; canopy of trees, logging area in rainforest, Francis Range Woopen Creek Road, 24.7 km in from Bruce Highway, NW of Innisfail, 350m, M.E.H. 69134, 9.vi.1983.

Leptogium lichenoides (L.) Zahlbr.

Most records of *L. lichenoides* from Australia appear to be erroneous, but a specimen from Blue Waterholes on the New South Wales Southern Tablelands seems to be an atypical form of that species (or possibly a closely related taxon). This specimen has a similar thallus and very similar apothecia but it is devoid of lobules and the basal part of the apothecial proper exciple is weaker and formed of periclinal hyphae near and into the margins.

However, *L. lichenoides* is known to be a widespread and notoriously variable species. A broad study of the proper exciple in specimens from a wide range of habitats is therefore needed before confident delimitation can be made. Further collections of the Australian taxon also are essential and searches in other cool montane areas, especially limestone habitats, in Australia and New Zealand are needed.

Specimens examined:
AUSTRALIA. NEW SOUTH WALES. Blue Waterholes, Coolemon Plain, 35°37'S 148°41'E, c. 1250m, D. McVean 6496, v.1964 (CBG).
PYRENEES. R. Spruce 4052, (1845-46) (AD).
UNITED STATES OF AMERICA. OREGON. Benton County, L.H. Pike 421, 24.ii.1973 (AD).
SWEDEN. SKÅNE. On beech, South forest Hallands Väderö, in the Kattagat, off the west coast near Torekov, W. A. & Linna Weber S15202, 17.vi.1958 (US, ex COLO).

THE WILSON TYPES

Reverend F.R.M. Wilson, a Presbyterian Minister at Kew, Victoria from 1877 to 1897 and a distinguished Australian lichenologist, published twenty papers on his lichen collections from Tasmania to Brisbane. His main collection was donated to the National Herbarium of Victoria (MEL) and a duplicate collection was purchased by The National Herbarium of New South Wales (NSW). Tragically most of the main collection was lost en route from MEL to Dr. G. Albo at the University of Messina, Sicilia (Italy). This loss means that the duplicate collection at NSW is the major part of the Wilson Herbarium now extant (Filson, 1976: 187-8).

Of the sixteen *Leptogium* taxa discussed here and described as new by Wilson, three have subsequently been reduced to synonymy under *Collema* species (Degelius 1974) and two others are doubtful, but they are listed below with brief comments.

1. **Leptogium atro-viride** F. Wilson, Journ. Linn. Soc., Bot. **28**: 357 (1891). "Habitat On trees in maritime scrub, Southport."

From Wilson's brief protologue of this species it may well be a *Collema* but unfortunately type material of the species has not been located.

2. **Leptogium biloculare** F. Wilson, Journ. Linn. Soc., Bot. **28**: 357 (1891). "Habitat ad arboris corticem in sylva montana, Mt. Macedon."

Lectotype here selected: "On tree Mt. Macedon Victoria by Rev F. R. M. Wilson April 1886"; NSW.

Two syntypes of this species are extant: one at BM and the other at NSW. The former has been remounted, as have all the specimens of *Leptogium* taxa published in the same Journal by Wilson (1891) and held at BM. Thus the original mounting sheet has been trimmed drastically and glued into an envelope; annotations have then been copied from the protologue in another person's handwriting. In addition, the only date present is the date of publication. The syntype at NSW, on the other hand, is annotated in Wilson's handwriting, viz.: "On tree Mt. Macedon Victoria by Rev F. R. M. Wilson April 1886". The name *Leptogium biloculare* is not present but 3 bilocular spores have been drawn in pencil near the upper righthand corner of Wilson's mounting sheet together with the numbers ".015 .15" and the word "colorless". Below these are the words "paraph.dist hyph[ae?] open colourless I asci blue" and near the upper lefthand corner is the number "139". In conclusion I consider that the annotations in Wilson's hand and the fact that his main extant collection is held at NSW are valid reasons for lectotypifying the NSW syntype.

3. **Leptogium caerulum** F. Wilson, Bot. Bull. Dep. Agric. Qd. **7**: 28 (1891). "Habitat On bark of trees in scrub, Southport, Queensland."

Type material of this species has not been located but Wilson's description of the thallus suggests that it probably is not a *Leptogium* (viz.: "... thinly strewed with white and sprinkled here and there with white farinose spots and marked with very slender longitudinal white lines; beneath tomentose, fuscescent, ..."). If there is an extant specimen it may well have been placed under another genus in the Wilson collection and a search through genera which may better fit the description could prove useful.

4. **Leptogium carneolum** F. Wilson, Bot. Bull. Dep. Agric. Qd. **7**: 29 (1891). "Hab. On trees in the Blackall Ranges.".

Specimens have been found which may possibly be syntypes of this species, but further study is needed before a judgement can be made as to lectotypification.

5. **Leptogium denticulatum** F. Wilson, Bot. Bull. Dep. Agric. Qd. **7**: 28 (1891). "Hab. On tree in maritime scrub, Southport."

= *Leptogium wilsonii* Zahlbr. [non *L. denticulatum* Nyl.].

The fertile original type material of this species probably was among those lost en route to Italy, but I believe that a sterile specimen present in the duplicate collection at NSW is a duplicate of Wilson's type collection. It is annotated by Wilson in ink as "*Leptogium urceolatum* Wilson, Southport Queensland leg Rev F R M Wilson 12 August 1890". This has been written over other annotations which are in pencil, viz: "1068 *Leptogium urceolatum* Wils.",with a sketch of a spore which has one end longer than the other near the upper right hand corner and written below the name "apothecia small disk spadices rufous concave margin pale much elevated Spores fusiform-ellipsoid, 5 septate with longitudinal division .02 x .008 mm. Rev F R M Wilson Queensland Southport 12 Aug 90". Although this is not exactly the same as the description of apothecia in Wilson's protologue, it is remarkably similar, viz.: Apothecia small, spadices rufous, concave; margin elevated, pallid, subfimbriate-crenulate. Spores fusiform-ellipsoid attenuate at both ends but more at one end than the other, 5 septate and with longitudinal division in the 4 middle cells; .02 x .008 mm. The name "*L. urceolatum* Wils." was never published; it is possible that following closer study Wilson observed the "subfimbriate-crenulate" apothecial margin which caused him to change his mind about the epithet of the taxon.

In view of the above annotations I consider this specimen to be part of the type material. In addition no other specimens have been found in Wilson's Southport collection that agree in any way with his protologue. Therefore, as the original part of the type collection cannot be located and probably is not extant, this NSW duplicate specimen becomes the holotype of the species.

Holotype: 1068 [as] "*Leptogium urceolatum* Wilson" "Southport Queensland by Rev F R M Wilson 12 August 1890"; NSW (*L. urceolatum* F. Wilson non edit.).

No other specimens of this species have been seen and the habitat in Southport and in most other coastal areas of south-eastern Queensland has been destroyed by resort development.

6. **Leptogium limbatum** F. Wilson, Vict. Nat. **6**: 63 (1889). "Habitat on back of trees in subalpine localities".

Lectotype here selected: "Leptogium limbatum Wilson On Prostanthera Mt. Macedon Victoria by F R M Wilson 1887", NSW; Isolectotype, BRI.

(*L. inflexum* var. *limbatum* F. Wilson, Proc. Roy. Soc. Vict. **5**: 158 (1893). "Hab.: on trees and mossy logs in sub-Alpine localities, Black Spur, Warburton, Mt. Macedon.")

Lectotype here selected: "115 On tree Warburton Victoria by F R M Wilson December 1885", NSW.

In his protologue Wilson (1889) described the thallus of *L. limbatum*, but he also described apothecia and spores which agree with those of *L. tasmanicum* F. Wilson, thereby basing his description on discordant units. He corrected his mistake, however, when describing *L. limbatum* again as sterile by using the statement "Apothecia invisa" (Wilson, Journ. Linn. Soc., Bot. **28**: 358, 1891).

Wilson considered *L. limbatum* to be allied to *L. inflexum* Nyl. (= *L. burgessii* Mont.) and later described a specimen as *L inflexum* var. *limbatum* (Wilson 1893: 158) which may have been intended as a recombination of his earlier species. The brief protologue, however, gives no specific indication that this is so but the description does match the two specimens in NSW which Filson (1986: 134) considered to be syntypes of Wilson's variety. J. Müller (1896: 87) considered that Wilson's variety did not belong to the Mallotium (tomentose) group and published it as a new combination, viz.: *Leptogium tremelloides* var. *limbatum.* Subsequently other authors have placed *L. limbatum* among the tomentose *Leptogium* species (e.g. Galloway 1985: 253), but although this species sometimes has conspicuous and somewhat dense patches of rhizines, it is never uniformly tomentose.

The squamuliform isidia of *L. limbatum* suggest a possible relationship with the New Zealand species *L. crispatellum* Nyl., but this latter species lacks conspicuous rhizines. So far I have been unable to locate any fertile specimens of the latter amongst material from New Zealand herbaria to compare with those of the former species. My judgement is, however, that *L. limbatum* seems to be more closely related to *L. tasmanicum*, which also has conspicuous and often dense patches of rhizines. In addition the spores of both species have obtuse to broadly obtuse apices. The latter species differs from *L. limbatum* by its much larger apothecia and the absence of isidia.

7. **Leptogium olivaceum** F. Wilson, Vict. Nat. **6**: 62 (1889).
"Habitat amongst mosses on granitic rocks."
Lectotype: BM (Degelius 1974: 135).
= *Collema subconveniens* Nyl. [Degelius l.c.].

8. **Leptogium olivaceum** var. **granulatum** F. Wilson, Journ. Linn. Soc., Bot. **28**: 357 (1891). "Habitat ad arborum cortices in Warrnambool et Kew et Gippsland; frequens."
Lectotype in BM (Degelius 1974: 140).
= *Collema subflaccidum* Degelius [Degelius l.c.].

9. **Leptogium olivaceum** var. **limbatum** F. Wilson, Journ. Linn. Soc. Bot., **28**: 357 (1891). "Habitat ad arborumcortices in Warrnambool."
Lectotype in BM (Degelius 1974: 89).
= *Collema kaiuense* H. Magnusson [Degelius l.c.].

10. **Leptogium pecten** F. Wilson, Journ. Linn. Soc., Bot. **28**: 358 (1891). "Habitat ad arborum cortices emortuus in Mordialloc et Mt. Macedon et Glenmaggie; infrequens"

Lectotype here selected: "On but of titree Mt Macedon Victoria by Rev. F.R.M. Wilson February 1887"; NSW.

The specimen selected as lectotype with its subsquamulose habit and narrow lobules agrees more with Wilson's protologue than the other syntypes.

L. pecten was placed in synonymy under *L. crispatellum* Nyl. by Galloway (1985: 251) but the former differs from the latter by its usually subsquamulose, more closely appressed habit, its often lobulate but non-isidiate thallus and commonly fertile state with apothecia (0.3-)0.5-2mm diameter.

11. **Leptogium philorheuma** F. Wilson, Proc. Roy. Soc. Vict. **5**: 157 (1893).
"Hab. on mosses and rocks in the channels of streams, Curdies Creek, Lorne, Tallarook."

Lectotype here selected: "On moss in channel of stream Lorne Victoria by Rev. F.R.M. Wilson May 1887" [annotated as "*Leptogium dactylinum* Tuckerman"], MEL; isolectotypes, BRI, BM.

Wilson first reported this species (1891: 358) as *L. dactylinum* Tuck. and cited that earlier reporting in his protologue (vide in ops. cit., scrips.: "Named by Dr. Knight as *L. dactylinum* and so reported by me (Trans. Linn. Soc. 1890)."

Wilson's species is similar to *L. dactylinum* in its often olivaceous thallus colour but differs from it by the absence of isidia, its larger apothecia and its broader spores (10-13 µm) which have obtuse to broadly obtuse apices.

L. philorheuma has also been placed in synonymy under *L. marginellum* S. Gray [e.g. Zahlbruckner (1925: 144) and Weber and Wetmore (1972: 56)]. The former species differs from the latter, however, by its non-rugose thallus and its larger, laminal apothecia which are non-isidiate and not commonly aborted.

A more likely relationship probably would be one between *L. philorheuma* and some forms of *L. pecten*: both species have spores with obtuse to broadly obtuse apices and they have similar apothecia. The former species differs from the latter by its larger, often olivaceous thallus which is never subsquamulose and lacks linear to subterete lobules. Further study of this species and the *L. pecten* group is needed, however, as there are several doubtful elements within and close to the group.

12. **Leptogium tasmanicum** F. Wilson, Pap. Proc. R. Soc. Tasmania 1892-93: 144 (1893)." Hab. on mossy earth, Brown's River."

Wilson annotated several specimens from Kilmore and Mt. Macedon in Victoria with the name "*Leptogium kilmorense*." On the other hand he must have originally considered that his later collection from Brown's River in Tasmania belonged to a different taxon because he annotated the two specimens of this collection with the name "*Leptogium tasmanicum*." Later, however, he presumably recognized the Tasmanian specimens as belonging to the same taxon as his Victorian specimens and so changed the former name to "*Leptogium kilmorense*." With close observation the name "*Leptogium tasmanicum*" can be seen under the name "*Leptogium kilmorense*" on both mounting sheets. He obviously changed his mind a second time, however, and decided to publish the species as *Leptogium tasmanicum* but did not change his specimen annotation a second time.

There is no evidence that Wilson made more than one leptogium collection at Brown's River. Therefore these two specimens are considered here to be the holotype and isotype of the species.

Type: "*Leptogium tasmanicum* [overwritten with "*Leptogium kilmorense*"] Wilson on mossy earth Browns River Tasmania Rev. F.R.M. Wilson", holotype, NSW; isotype, MEL. [L. kilmorense non edit.].

13. **Leptogium tremelloides** var. **muscitegens** F. Wilson, Proc. R. Soc. Vict. **5**: 156 (1893). "Hab. on stems of mosses on trees, Warburton, Kurumburra."

Lectotype here selected: "On mossy tree Warburton Victoria by Rev. F.R.M. Wilson December 1885" [spec. with "5 septate" and "0.4" written near spore sketches in pencil at top right corner and "144" at top left hand corner]; NSW.

= *Collema subconveniens* Nyl. (bluish grey form).

14. **Leptogium victorianum** F. Wilson, Journ. Linn. Soc., Bot. **28**: 358 (1891). "Habitat inter muscos ad arbores et rupes abundans in lociis montantis, Mt. Macedon et Black Spur etc. Affine *L. chloromelo* Sw. et forsitan ejus varietas. Fig. 10 sporae duae".

Lectotype here selected: "On mossy log Black Spur Victoria, by Rev. F.R.M. Wilson 21 March 1885" [spec (a)], NWS; isolectotype [spec (b)], NSW.

(*Leptogium chloromelum* var. *victorianum* F. Wilson, Vict. Nat. **6**: 62 (1889). Habitat on mossy trees and rocks). Lectotype here selected: same as the lectotype of *L. victorianum* .

There are three syntype collections of this species, two of which are at NSW and the third at BM. The two at NSW are annotated in Wilson's handwriting, viz.: " On mossy log Black Spur Victoria by Rev. F.R.M. Wilson 21 March 1885" (2 specimens) and "On decaying log Mt. Macedon Victoria by Rev. F.R.M. Wilson June 1889" (3 specimens). The BM syntype, on the other hand, is not annotated in Wilson's handwriting. Here the problem again arises where Wilson's BM syntypes have been remounted and the annotations copied from the protologue in another person's handwriting (see under *L. biloculare*).

As stated by Filson (1986: 137) Wilson did not refer specifically to this variety in the protologue of *L. victorianum* and I have been unable to locate a specimen annotated as *L. chloromelum* var. *victorianum*. However, several diagnostic phrases and the habitat notes in the protologue of *L. victorianum*, when translated from Latin, match the diagnostic phrases and the habitat notes in the protologue of *L. chloromelum* var. *victorianum*. This leads me to believe that Wilson probably did intend to raise his variety to species rank but omitted to cite it as such. There is no incontestable evidence of Wilson's intentions, however, so it is considered prudent to simply place *L. chloromelum* var. *victorianum* in synonomy under *L. victorianum*.

L. victorianum differs from *L. chloromelum* by its broader, non-anastomosing thallus lobes which vary in thickness but do not have thickened ridges and often have superficial or marginal squamuliform isidia. It also differs by its laminal apothecia in which the basal part of the proper exciple is either poorly formed of periclinal hyphae or absent.

This species is common in moist forests of Victoria and Tasmania but it has not yet been collected from New Zealand and only one doubtful, atypical and sterile specimen has been collected from southern New South Wales.

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DISTRIBUTIONAL AND ECOLOGICAL NOTES ON HYPOCENOMYCE SCALARIS (LECANORALES, LECIDEACEAE) IN EASTERN NORTH AMERICA

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Abstract. *The tiny squamulose lichen* Hypocenomyce scalaris, *while easily overlooked, is nonetheless readily identified. Known North American range, based on 597 specimens, includes the Canadian provinces and most of the northern U.S., with outliers in Texas and the Dominican Republic at high elevations (2000+ m). The species also occurs throughout Eurasia and in Australia and New Zealand. In eastern North America, this lichen naturally grows in humid edge habitats with dappled shade: in wetter portions of pine barrens, shale barrens, oak savannah, and alvar vegetation; on bluffs, gorge rims, mountain crests, and beaches near large lakes and rivers; and in swamps, bogs, fens, and beaver meadows. Lawns, hedgerows, and arboreta are human-influenced habitats. North American substrates include a variety of trees with acidic bark (pH 4.0), most often Pinaceae (especially* Pinus rigida*), Cupressaceae, and Aceraceae, as well as acidic lignum and charred wood. Apothecia are infrequent, and mature ascospores have not been seen.* Hypocenomyce scalaris *reproduces vegetatively via wind-, water-, and animal-dispersal of its abundant soredia.*

This paper is dedicated to
Matthew F.J. Dirig and Kristin A. Barron
in appreciation for their company, assistance, and patience
on many long rambles seeking *Hypocenomyce scalaris*
in the Catskill Mountains of New York.

Introduction

Hypocenomyce scalaris (Ach.) M. Choisy (Lecideaceae, Lecanorales) is a tiny squamulose lichen that grows on tree bark, lignum, and charred wood. Easily overlooked because of its superficial resemblance to the primary squamules of *Cladonia*, it has not often been collected in North America, probably because it uncommonly bears apothecia. *Hypocenomyce scalaris* is, however, readily identified in the sterile state, even in the field. I expect that its obscurity is due to the lack of an adequate illustration, and to incomplete and scattered descriptions of its habitats. In this paper I present illustrations, distributional notes, and observations on the habitats, substrates, and life history of this beautiful small lichen, with special reference to eastern North America.

Hypocenomyce scalaris is easily identified by its unique greyish-green, olive, or sometimes tan, marginally and ventrally sorediate, imbricate, convex squamules (Figs. 1-8) and C+ red, PD- reactions. This species contains lecanoric acid and "3 scalaris unknowns" (Hale, 1979; Timdal, 1984). It is not necessary to use thin-layer chromatography (TLC) to identify *H. scalaris*.

Spot tests on *H. scalaris* should be made while watching through a dissecting microscope. A C+ reaction in this species produces an instantaneous but evanescent deep red on the cortex, medulla, and soredia, unlike subtle C+ reactions in some lichens. *Fresh* C (undiluted household bleach that has been stored in an opaque container) must be used, as stale reagent can result in incorrect C- reactions. A C+ red reaction is so diagnostic that an additional PD test is unnecessary to identify *H. scalaris*.

A similar species, *Hypocenomyce anthracophila* (Nyl.) P. James & G. Schneider, appears to be somewhat rarer in North America, usually occurs on charred wood, is frequently fertile, and has much smaller squamules with C-, PD+ red reactions (fumarprotocetraric acid). *Hypocenomyce friesii* (Ach.) P. James & G. Schneider, another member of this group, has convex esorediate squamules the same size as those of *H. scalaris*, gyrose apothecia, and reacts C-, PD- in both cortex and medulla. It occurs in similar habitats, especially on charred substrates. Thorough descriptions and illustrations of *H. anthracophila* and *H. friesii* were provided by Schneider (1979) and Timdal (1984). *Cladonia* squamules growing in the same niches are usually larger, bluer green, and more heavily sorediate, with crenulate margins and C- reactions.

Hypocenomyce scalaris has been reported in the American literature under a number of names, now regarded as synonyms:

Psora ostreata Hoffm., 1796: Fink (1935), Nearing (1962).
Lecidea scalaris (Ach.) Ach., 1803: Lowe (1939), Wetmore (1968), Brodo (1968), Hale (1969), Bird (1970).
Lecidea ostreata (Hoffm.) Schaer., 1828: Fink (1935), Nearing (1962), listed as synonym.
Psora scalaris (Ach.) Hook., 1844: Hale (1979).

Biatora ostreata (Hoffm.) Fr., 1846: Tuckerman (1888).
A complete synonymy, including basionyms, was presented by Schneider (1979). Nearing (1962), who coined vernacular names for all species treated in his book on northeastern North American lichens, appropriately christened *H. scalaris* the "Oyster Lichen" because its "flakes ... suggest tiny oyster shells." This species is the type of its genus.

Hypocenomyce scalaris is easily discovered on bark or lignum of *Pinus, Acer*, and other trees (Table 1). Thalli commonly grow near the bases of tree trunks, but may reach 6-10 m above ground in ideal situations. A hand lens facilitates distinguishing *H. scalaris* from other squamulose or crustose lichens growing on the same trees. Although readily seen when present, the Oyster Lichen is not always easy to find. Typically, only four or five specimens are encountered during several hours of field work.

Methods

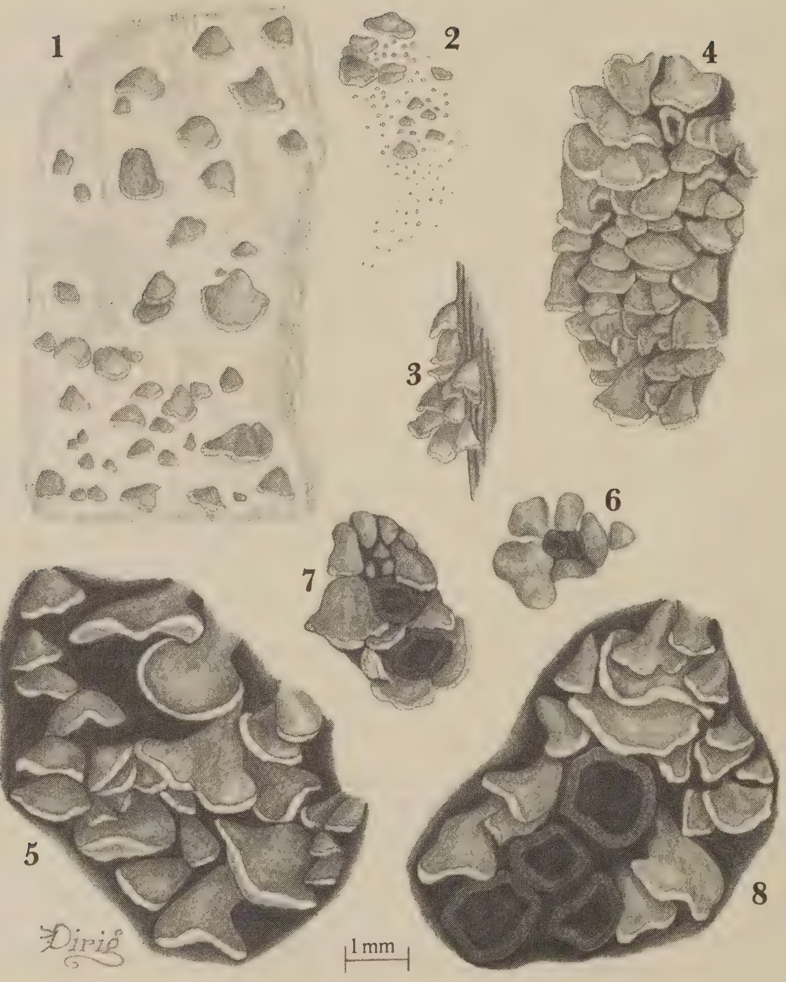
Collections of *H. scalaris* were first made in 1976-1978 while conducting general lichen sampling in eastern New York. Once identified, the lichen was frequently noticed, and in 1979-1980, ca. 100 collections were made at sites with pine barrens vegetation throughout northeastern North America. The dominant canopy tree in these areas is *Pinus rigida*. Deliberate searches for *H. scalaris* were conducted whenever *P. rigida* was found, after learning of its close association with this tree (Brodo, 1968: 170). Preparation of earlier specimens and subsequent field work showed *H. scalaris* to commonly grow on several other members of the Pinaceae and also on *Acer rubrum*. At this point, general searches were made on available trees, and it was collected wherever found.

Hypocenomyce scalaris specimens were borrowed from CANL, CUP, DUKE, FH, MICH, NY, NYS, US, and from Claire K. Schmitt's private herbarium. In all, 387 specimens were examined, including 177 personal collections (see Appendix). Photocopies of labels or label transcriptions of all specimens seen have been filed at CUP. Label data from an additional 210 specimens in MIN were kindly provided by Clifford M. Wetmore (also in CUP). Except for a few duplicates deposited elsewhere, I have not seen the MIN material.

Results

Geographic Distribution

Based on specimens seen, the North American range of *Hypocenomyce scalaris* includes Quebec, Ontario, Manitoba, Alberta, British Columbia, Northwest Territories, and Yukon in Canada; and Maine, New Hampshire, Vermont, Massachusetts, New York, New Jersey, Pennsylvania, Virginia, West Virginia, North Carolina, Ohio, Michigan, Minnesota, Wisconsin, South Dakota, Colorado, Washington, California,



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and Texas in the United States (Figs. 9-10). It has been most thoroughly documented in New York, where it is known from 27 counties. Western Hemisphere specimens used in compiling the maps and Table 1 are listed in the Appendix.

Literature records add New Brunswick (Gowan & Brodo, 1988) and Saskatchewan (Brodo, 1968; Vitt *et al.*, 1988) in Canada, and these U.S. states: Idaho (Timdal, 1984), Wyoming (Wetmore, 1968, and his MIN specimens; Timdal, 1984), and Arizona (Darrow, 1950; Weber, 1963; Brodo, 1968; Timdal, 1984; and MIN specimens). Tennessee and Montana

Figures 1-8: Freehand drawings of *Hypocenomyce scalaris* (Ach.) Choisy, all to the same scale. **1.** Sparse juvenile squamules which grew on a decorticated *Tsuga canadensis* between 1966 and 1979, Catskill Mountains, N.Y. (*Dirig L-1395*). **2.** Juvenile squamules showing soredial shower trapped in textured surface of *Pinus rigida* bark, Westfield, Mass. (*Dirig L-1521*). **3.** Side view of maturing, massed squamules on *P. rigida* bark interstice, Albany Pine Bush, N.Y. (*Dirig L-717*). **4.** Maturing massed squamules, some younger, on *P. rigida*, Albany Pine Bush (*Dirig L-1406*). **5.** Fully mature squamules on the right, younger ones on the left, on decorticated *Pinus strobus*, Catskill Mountains (*Dirig L-1396*). **6.** Young apothecia among squamule "buttons" not yet showing their sorediate rims, on burned *P. rigida*, Clinton County, N.Y. (*Dirig L-1535*). **7.** A later stage of apothecial and squamule development (*L-1535*). **8.** Squamules and apparently mature apothecia on charred wood, Adirondacks, N.Y. (*Lowe 6044*). No ascospores were found in this collection.

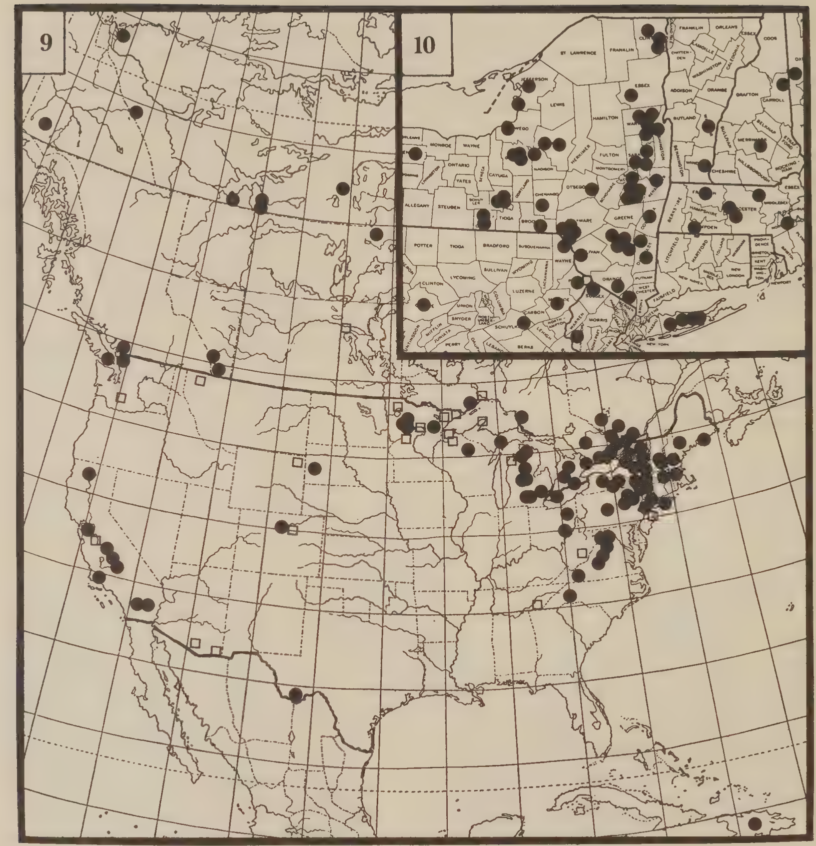
were also added by MIN specimen data. The range map for this species in Hale (1979) included the additional provinces of Labrador, Nova Scotia, and Newfoundland and the states of Connecticut, Rhode Island, Oregon, and New Mexico in the known American range, but no specimens from these areas were accessioned at US (October 1989).

Hypocenomyce scalaris thus is widely distributed across northern North America, occurring at higher elevations southward—in the Appalachians at least to North Carolina and Tennessee, and in the Coast Ranges, Sierra Nevada, and Rocky Mountains of the West. Not surprisingly, it appears to be absent from the Great Plains and drier parts of the West, where suitable habitats probably do not occur. Einar Timdal wrote (letter to me, 17 August 1989): "I spent three months in Colorado, Utah, New Mexico, and California last year, and can testify to its scarcity in arid western North America."

Specimens from Big Bend National Park, Brewster County, Texas (*Wetmore 18361*, US; and three others in MIN) were the southernmost for the U.S. A Caribbean specimen from the Dominican Republic (*Buck 5292*, NY) was the most southerly seen from this hemisphere, while the most northern locality was at 64° 30'N, 135° 06'W in the Yukon (*Scotter 19382*, CANL).

Outside of North America, *H. scalaris* is widely distributed from Scandinavia and the British Isles to Morocco, and across Europe and the U.S.S.R. to Japan; in Australia (Timdal, 1984, and specimens loaned to me); and in New Zealand (Galloway, 1985).

Altitudinally, *Hypocenomyce scalaris* is found in the Western Hemisphere from near sea level on Long Island, New York, and on Mount Desert Island in Maine to much higher elevations in western North America—1590 m (Alberta), 1130 m (Yukon), 1370 m (South Dakota), 1680-1710 m (Colorado), 800-1800 m (California), and to 2260 m in Texas and 2140 m in the Dominican Republic. In Europe it reaches 730-



Figures 9-10: Distribution of *Hypocenomyce scalaris*, based on specimens seen (solid circles) and MIN records (open squares). **9.** Western Hemisphere distribution. **10.** Detailed distribution in the northeastern United States.

1510 m in the Alps, and it has been collected at 640 m in Australia. Timdal (1984) reported this lichen from sea level to 1000 m in Norway and Sweden.

Substrates

This lichen occurs on a wide variety of woody substrates (Table 1). The commonest substrates in material examined, with number of specimens collected from each in parentheses, were *Pinus rigida* (102), *Pinus strobus* (30), charred or burned wood (29), lignum (23), *Acer rubrum* (16), wooden fences (12), *Tsuga canadensis* (12), and *Prunus serotina* (9). Of 387 records, 217 were from conifers (167 of these from *Pinus*); 65 from some form of lignum; and 22 from *Acer*. While not statistically important, these figures suggest substrate preferences. All but one of the specimens seen were collected from wood or bark, although Timdal (1984) noted that *H. scalaris* rarely may be terricolous or saxicolous, once was found on an old rope, and once was seen epiphytic on the rock tripe lichen *Lasallia pustulata* (L.) Mer. (Umbilicariaceae). I saw specimens collected from barn walls in Finland (*Goward 79-38l*, CANL) and Sweden (*Marklund s.n.*, US), and from 200-year-old brick in England (*Cryton s.n.* in my herbarium). Several authors mentioned charred wood as a primary substrate [Tuckerman (1888), Fink (1935), Lowe (1939), Nearing (1962), Wetmore (1968), Brodo (1968, 1981), Bird (1970), Hale (1979), Timdal (1984), Galloway (1985)], but Timdal (1984) suggested that *H. scalaris* is "most common on burnt wood but has more frequently been collected on substrata that have not been charred, owing to the general scarcity of burnt wood." I.M. Brodo (pers. comm., August 1989) noted that most charred stumps of the right age in southern Ontario have some *H. scalaris*, if other conditions are right.

Hypocenomyce scalaris was commonest on *Pinus sylvestris* in Sweden and Norway, according to Timdal (1984), who also recorded it from the following trees not mentioned in Table 1: *Picea abies*, *Acer platanoides*, *Alnus glutinosa*, *Castanea sativa*, *Catalpa bignonioides* and *C. ovata*, *Fraxinus excelsior*, *Rhamnus cathartica*, and *Sorbus* sp.

Substrate pH is highly acidic, consistently 4.0, as determined using *pHydrion MIKRO 0 to 11N* tape (available from Micro Essential Laboratory, Brooklyn, NY 11210, USA). Bark of the following substrate trees has pH 4.0: *Larix laricina; Picea abies, P. mariana, P. rubens; Pinus banksiana, P. resinosa, P. rigida, P. strobus, P. sylvestris, P. virginiana; Pseudotsuga menziesii; Thuja occidentalis; Carya ovata; Quercus coccinea, Q. prinus; Prunus serotina*; *Ulmus americana*; and *Acer rubrum*. Charred *Pinus resinosa* bark had a slightly higher pH of 4.2, while stump charcoal in a burned New York deciduous forest was pH 4.5. Decorticated lignum and bark of *Tsuga canadensis* had the same pH (4.0). Bark of trees upon which *H. scalaris* has only rarely been found had a slightly higher pH [*Acer saccharinum, Betula populifolia*, and *Robinia pseudo-acacia* (4.3); *Quercus bicolor* (4.5); and *Juniperus virginiana* (4.7)]. Two-hundred-year-old brick had pH 4.0 Bark pH of trees upon which this lichen has never been found is higher: *Populus deltoides* and *Salix* sp. (5.0).

Mature bark plates of *Pinus rigida* have a distinctively textured surface (appearing web-like or pitted to the naked eye or under slight magnification) in which the soredia of *H. scalaris* are readily caught (Figs. 11-12). I have consistently found *H. scalaris* on *P. rigida* wherever a population of these trees was naturally encountered. The most striking example of this was on Jensen Hill in Hancock Town, Delaware County, New York, where in a state forest preserve of 6 sq. km, the single individual of *P. rigida* on the entire mountain top had an abundant

Table 1: Substrates of 387 Hypocenomyce scalaris specimens from the herbaria cited in the Appendix.

SUBSTRATE	NO.	GEOGRAPHIC AREAS
Pinaceae		
Larix decidua	6	N.A. (New York). EUROPE (Sweden, Denmark, Austria, Estonia).
Larix laricina	3	N.A. (Michigan).
Picea mariana	3	N.A. (New York, Northwest Territories).
Picea rubens	2	N.A. (New York).
Picea sp.	2	N.A. (Ontario, Northwest Territories).
Pinus banksiana	6	N.A. (Michigan, Minnesota, Northwest Territories).
Pinus echinata	2	N.A. (Ohio).
Pinus ponderosa	5	N.A. (New York, South Dakota, Colorado, California).
Pinus resinosa	6	N.A. (New York, Ontario, Michigan).
Pinus rigida	102	N.A. (Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, West Virginia, Virginia, North Carolina, Ohio).
Pinus strobus	30	N.A. (Quebec, Ontario, Massachusetts, New York, Pennsylvania, West Virginia, Ontario, Michigan).
Pinus sylvestris	3	EUROPE (Finland, Sweden).
Pinus virginiana	2	N.A. (West Virginia, Virginia).
Pinus sp.	11	N.A. (Quebec, Ontario, New York). EUROPE (Finland, England, Germany, Czechoslovakia).
Pseudotsuga menziesii	3	N.A. (Alberta, British Columbia, Washington).
Sequoia sempervirens	1	N.A. (California).
Tsuga canadensis	12	N.A. (Vermont, New York).
Conifer (unspecified)	9	N.A. (New York, Ontario). EUROPE (Sweden, Denmark, Germany, Austria).
Cupressaceae		
Chamaecyparis thyoides	1	N.A. (Massachusetts).
Juniperus flaccida	1	N.A. (Texas).
Juniperus virginiana	1	N.A. (New York).
Juniperus virginiana or *J. communis*	1	N.A. (New York).
Thuja occidentalis	4	N.A. (New York, Michigan, Ontario).
"Cedar"	1	N.A. (California).
Juglandaceae		
Carya ovata	1	N.A. (New York).
Betulaceae		
Betula populifolia	1	N.A. (New York).
Betula sp.	2	EUROPE (Germany, Sweden).
Fagaceae		
Quercus alba	2	N.A. (New York, Michigan).
Quercus bicolor	1	N.A. (New York).
Quercus coccinea	1	N.A. (New York).
Quercus prinus	1	N.A. (New York).
Quercus robur	1	EUROPE (Germany).
Quercus sp.	3	EUROPE (Denmark, Czechoslovakia).

(continued on next page)

Ulmaceae		
Ulmus americana	2	N.A. (New York, Ohio).
Ulmus sp.	1	EUROPE (England).
Rosaceae		
Amelanchier laevis	1	N.A. (New York).
Crataegus sp.	1	EUROPE (Denmark).
Prunus serotina	9	N.A. (New York, Pennsylvania).
Leguminosae		
Robinia pseudo-acacia	1	N.A. (New York).
Aceraceae		
Acer rubrum	16	N.A. (Massachusetts, New York, Michigan).
Acer saccharinum	3	N.A. (New York).
Acer saccharum	2	N.A. (New York).
Acer sp. (cultivated)	1	N.A. (British Columbia).
Bignoniaceae		
Catalpa speciosa	1	N.A. (Ontario).
Myrtaceae		
Eucalyptus macrorhyncha	1	AUSTRALIA (Australian Capital Territory).
Eucalyptus sp.	1	AUSTRALIA (Victoria).
Oleaceae		
Fraxinus americana	1	N.A. (New York).
Fraxinus sp.	1	N.A. (Ontario).
Miscellaneous		
wooden fences	12	N.A. (Quebec, Ontario, Michigan).
barn walls	2	EUROPE (Finland, Sweden).
charred or burned stumps, logs*	29	N.A. (Quebec, Vermont, New York, Ontario, Michigan, Minnesota, Wisconsin, Manitoba, Alberta, California). CARIBBEAN (Dominican Republic). EUROPE (Sweden). AUSTRALIA (New South Wales).
lignum	23	N.A. (New York, Pennsylvania, Michigan, Ontario, Northwest Territories). EUROPE (Scandinavia, Germany). AUSTRALIA (Victoria).
unidentified, unspecified woody substrates	48	worldwide.
200-year-old brick	1	EUROPE (England).

*18 additional collections on identified charred substrates are included under the species or genus. This category is used only for collections from undetermined burnt lignum. Total collections on charred substrates = 47.

growth of this lichen on its trunk. This tree was ca. 13 km from the nearest individuals of its species. My searches in the southern Appalachians also targeted this tree as a predictable substrate, always successfully. *Pinus sylvestris* bark very closely resembles bark of *P. rigida*, probably explaining its frequency as a European substrate (Timdal, 1984). Charred wood or bark is similarly pitted. All woody substrates I have seen (Table 1) have highly textured surfaces or bark plate interstices, which seem to be requisite for *H. scalaris* colonization and growth.

Habitats

This tiny epiphyte grows *in the dappled shade of humid edge habitats*. Such situations are found in a wide array of naturally occurring, open-canopy vegetation types, as well as in human-influenced ones which approximate them.

NATURAL OPEN-CANOPY VEGETATION falls into three general types, described below as they relate to *H. scalaris* habitats:

(1) Vegetation exhibiting strong edaphic influences includes *PINE BARRENS* on acid sand, *SHALE BARRENS* on crumbling shale outcrops, *OAK SAVANNAH* on calcareous sand, and *ALVAR* on limestone pavement. All are xeric, fragile, relatively rare, and to some extent fire-maintained communities with highly specialized biotas. The vegetation is characterized by scattered large trees (conifers and *Quercus*) among an extensive shrub and herb layer. Because of fires, shifting and easily disturbed sand, or eroding rock, these areas may be in a constant state of natural flux. In all cases, *H. scalaris* prefers humid sections.

This lichen thrives on *Pinus rigida*, the dominant tree in pine barrens vegetation, where periodic fires maintain an open, savannah-like aspect [Benton (1976), Little (1979)] and incidentally provide abundant charred bark or lignum substrates. Evergreen branches of the scattered pines provide the constant dappled shade preferred by this lichen. At the Pine Bush, Albany County, New York (a large inland pine barrens), *H. scalaris* does not occupy *P. rigida* trunks in the most xeric, open areas on the dunes, where high pine branches do not furnish shade, but instead prefers sand roads, trails, and utility pole corridors where the vegetation is more dense and shady, and where an adjacent wetland supplies humidity. In interfingered kettle bogs, swamps, marshes, and ravines this lichen grows on *Pinus strobus* and *Acer rubrum*. In similar pine barrens vegetation on the eastern edge of the Adirondack Mountains in Clinton County, New York, *H. scalaris* grows on *P. rigida, P. strobus*, and *P. resinosa*.

In West Virginia shale barrens (described by Keener, 1983), *H. scalaris* was found on *Pinus rigida* and *P. virginiana* in partly shaded situations, and on *P. strobus* and lignum edging a stream at the base of the slope. At Pinery Provincial Park on the Lake Huron east shore, Ontario, this lichen grew on *P. resinosa* and *P. strobus* in oak savannah vegetation stabilizing alkaline sand dunes. *Pinus strobus* and *Tsuga canadensis* were its substrates in a swampy section of alvar vegetation at Limerick Cedars, Jefferson County, New York (briefly characterized by Slack *et al*., 1988).

(2) *BLUFFS, GORGE RIMS, MOUNTAIN CRESTS*, and *BEACHES* have a second type of open-canopy vegetation quite similar to the preceding. These are sunny, often xeric habitats with persistent edges

enforced by geography or elevation, and humid air from adjacent large lakes or rivers. Because of unstable soil, steep slopes, and occasional fires, such habitats may also be in a state of natural flux.

Bluffs and gorge rims are common throughout the Finger Lakes of central New York and around the Great Lakes, where scattered *Pinus rigida, P. strobus,* and *Tsuga canadensis* are substrates in acid-soil situations, and *Juniperus virginiana* and *Thuja occidentalis* serve at limy sites. *Hypocenomyce scalaris* grows on *Prunus serotina* and *Acer rubrum* trunks in public picnic areas on Lake Ontario east shore beaches in Oswego and Jefferson Counties, New York. In the windswept pine barrens of Ice Caves Mountain National Landmark on Shawangunk Mountain summits, Ulster County, New York, this lichen is found on the dwarf, bonsai-like form of *Pinus rigida* near Lake Maratanza at 695 m elevation. In the Blue Ridge Mountains of Virginia and North Carolina, *H. scalaris* grows on large *P. rigida* on exposed crags.

(3) Wetlands have a third kind of natural open-canopy vegetation maintained by water table and periodic or seasonal flooding. *Pinus strobus, Acer rubrum,* and *Tsuga canadensis* grow on hummocks between open pools in New York *SWAMPS*, providing the humid, shady edges preferred by *H. scalaris*. *SPHAGNUM-HEATH BOGS* have similar hummock-and-pool vegetation around the outside, with an often sharply defined edge where the floating *Sphagnum*-heath mat begins. In New York and New England bogs, *H. scalaris* grows on *Pinus strobus, Tsuga canadensis, Picea rubens, P. mariana, Chamaecyparis thyoides*, and *Acer rubrum*. In the open vegetation of Michigan and Ontario *FENS*, this lichen is found on *Thuja occidentalis, Pinus banksiana, P. strobus,* and *P. resinosa*. *BEAVER MEADOWS* are a frequent habitat in the Catskill Mountains, New York, where dammed ponds flood and drown *Pinus strobus, Tsuga canadensis*, and *Acer rubrum*, providing abundant lignum for colonization.

HUMAN-INFLUENCED HABITATS: European colonization of North America resulted in drastic changes in the native vegetation when vast tracts were cleared for settlements and agriculture; Native American dwelling, tilling, and burning practices had influenced this to a lesser extent for centuries before (Russell, 1980; Cronon, 1983). Human manipulations of this sort invariably produce abundant edge habitats, some of which have been colonized by *H. scalaris*.

SHADE TREES (usually *Pinus* or *Acer*) planted or left on lawns, in cemeteries and arboreta, and along roadsides are a common example. Huge *Acer saccharinum* and *Quercus alba* trees on expansive lawns at Cornell University, Ithaca, New York, left from original forest, have *H. scalaris* growing on their trunks. It also lives on planted 60-year-old *Pinus ponderosa* on Comstock Knoll at the Cornell University arboretum, probably derived from colonies on nearby native *P. strobus*. Large *Prunus serotina* in *FENCEROWS* and *HEDGEROWS* support luxuriant colonies of this lichen. Conifer *FENCE POSTS*, especially in eastern Canada and California, and *BARN LUMBER* in Scandinavia have provided substrates.

Its unexpected appearance on 200-year-old *BRICKS* in England has recently been noticed (Mark R. D. Seaward, pers. comm., August 1989), as has its spread in Europe, particularly Germany (Philippe Clerc, pers. comm., August 1989). These artificial situations, where lignum or trees of the right species and age grow along humid edges with a nearby source of the lichen, closely mimic the natural habitats it occupies. *Hypocenomyce scalaris* is often a pioneer colonizer in such places.

I looked unsuccessfully for the Oyster Lichen in dark, virgin conifer forests in the Adirondacks, although Lowe (1939) frequently found it there in more open, burned areas. In less shady places or on deciduous trees not shaded throughout the year by foliage, *H. scalaris* often occurs on the east (lee) side of the trunks, where it is perhaps sheltered from dessicating westerly winds and afternoon sun.

Life Cycle

The life cycle of *H. scalaris* proceeds as follows: (1) A wind-, water-, or animal-borne soredium becomes enmeshed in the textured surface of an appropriate woody substrate. Soredia presumably attach themselves to the substrate via hyphae and "jelly," as described by Ott (1987) for other lichens, although this was not observed in *H. scalaris*. (2) Juvenile squamules develop singly or in small clusters, but rarely overlap. These first grow as thallus "buttons" which maximally reach 0.1-0.5 (-1.0) mm wide and 0.2-0.3 mm high, and show minimal sorediate rims (Fig. 1). Much smaller squamules growing among and below these probably result from soredia shed from developing older squamules on the same tree. Indeed, some specimens of this age show a soredial shower trapped in the textured bark surface below older squamules (Figs. 2, 11-12). (3) Squamules continue to grow, eventually reaching 1.3-2.0+ mm wide and 1 mm high (Figs. 3-5). At this mature stage, squamules are often imbricate and have heavily sorediate rims (Fig. 11). Abundant soredia may be disseminated to adjacent trees, reinitiating the life cycle. Rate of squamule growth has not been documented, although I expect that mature squamules may be several years old, and that dense squamule colonies have developed over decades. The growth on one tree or even on several adjacent trees may be clonal, and is probably quite slow to develop.

Eastern substrate trees may attain ages of 200+ years in *Pinus rigida*, 200-350 years in *P. strobus*, to 300 years in *P. resinosa*, to 600+ years in *Tsuga canadensis*, 125-150 years in *Acer rubrum* and *A.*

Figures 11-12: Scanning electron micrographs of *Hypocenomyce scalaris* collected from *Pinus rigida*, Westfield, Mass. (*Dirig L-1521*). **11.** Sorediate squamule margins, showing shed globose soredia caught in bark surface at bottom (x182). **12.** Shed soredia enmeshed in highly textured bark (x470). Photographs by John V. Freudenstein.

11

12

saccharinum, and 150-200 years in *Prunus serotina* (Collingwood & Brush, 1984). Such longevity implies a stable growth site which may last from one to several centuries. Assuming that a bole in an appropriate habitat were colonized after the first few decades of growth required to produce mature bark plates, *H. scalaris* ideally might remain on the same tree throughout its life and for many years after on its lignum or charcoal. Of course, individual bark plates do not last for more than a few years, but the constant soredial shower from mature squamules would insure persistence of the lichen on the tree as long as proper conditions continued. In California, the Oyster Lichen grows on *Sequoia sempervirens* (*Hale 56551*, US), which may live 2100+ years, and on *Sequoiadendron giganteum* (Timdal, letter, 17 August 1989), which may reach 3400-4000+ years in age (Collingwood & Brush, 1984). This approaches maximum potential stability for a living woody substrate.

Apothecia

Hypocenomyce scalaris is not often found in the fertile state. Only 68 of the 387 collections examined bore apothecia, and many of these were older specimens collected before the widespread adoption of spot test and TLC identification techniques, when apothecia were more important in keying. I personally found fertile *H. scalaris* only three times. This lichen appears to fruit much more commonly when growing on a charred substrate: 22 of the 68 fertile collections were on charred wood, and 22 of 47 collections on charred substrates were fertile.

Apothecia probably develop soon after colonization, and first appear as concave black "buttons" ca. 0.2-0.3 mm in diameter amid juvenile squamules that are not yet sorediate-margined (Fig. 6). At a later stage, they are 0.6-0.8 mm across, and the surrounding squamules show sorediate rims (Fig. 7). Full-sized apothecia are rhomboid or trapezoidal, pruinose or matte black with a planar hymenium, reach 1.3 mm in diameter, and are usually surrounded by mature squamules (Fig. 8). Judging from the apparently slow growth of squamules, apothecia probably develop over several years. Heavily fertile material may have poor squamule and soredial development.

Schneider (1979) and Timdal (1984) figured the hymenial structures, and Jahns (1983) and Wirth (1987) published excellent color photographs of the squamules and apothecia of this species, all from European material. Vitt *et al.* (1988) also illustrated fertile *H. scalaris* in color in their field guide to western North American cryptogams. Mature ascospores have not yet been found in this lichen (Schneider, 1979; Timdal, 1984; and 10 apothecial squashes of heavily fertile collections microscopically examined by me). Mature ascospores should be sought in the largest available apothecia among masses of heavily imbricate mature squamules that are several decades old. Timdal (letter, 17 August 1989) wrote, "I am convinced that [the] apothecia ... are artifacts of a pre-sorediate stage/species. Does the strong correlation between burnt wood and fructification mean that burnt wood was the main substrate for the non-sorediate ancestor of present *H. scalaris*?"

Dispersal

Reproduction in *H. scalaris* appears to be constant and entirely vegetative. Soredia produced beneath and at the rims of individual squamules are spherical masses of hyphae surrounding central green algal cells, ca. 0.05 mm in diameter, and float on water (Figs. 11-12). Several dispersal methods are suggested: (1) When moist, soredia can be carried by wind for at least short distances. This was proved by holding moistened bark on which mature *H. scalaris* grew before a large revolving window fan for several minutes, and trapping airborne soredia on moistened filter paper disks held vertically a few cm downwind. (2) Beetles and other invertebrates that crawl over thalli undoubtedly disperse soredia on the same tree and perhaps to adjacent ones. Soredia clung to the hairy abdomens and elytra of dead Lampyrid, Cerambycid, and Elaterid beetle specimens (but *not* to the hairy bodies of Noctuid moths!) which were brushed over moistened growths of this lichen. (3) Trunk-climbing birds like nuthatches (Sittidae), creepers (Certhiidae), and woodpeckers (Picidae) surely pick up soredia on their feathers and carry them to other trees, much in the manner of pollen transfer on the hairy bodies of bees. The fur of arboreal mammals probably similarly transports soredia. Feathers and camel's-hair paint brushes drawn over moistened thalli picked up abundant soredia. (4) Water trickling down the trunk during rain storms, snow melt, or heavy dews likewise spreads soredia on the same tree. This was proved by holding wet filter paper at the bottom of bark plate interstices covered with *H. scalaris*, gently applying water with a dropper at the top, and retrieving soredia from the filter paper a few minutes later. Moistened squamules released soredia readily, but dry ones did not. This may explain the regular absence of the Oyster Lichen in persistently dry habitats. Lawrey (1984), speaking generally of lichens, reported that wet thalli release soredia slowly over a longer period of time, and release more soredia overall, than dry thalli.

Discussion and Conclusions

The abundant presence of this lichen in a naturally occurring edge habitat indicates a prime, healthy, and perhaps ancient situation that is worthy of conservation thought and action. All of the natural open-canopy vegetations mentioned above (except swamps and beaver ponds) are relatively rare, and may support specialized or even endemic biotas that are easily destroyed by human activities. Fortunately, many persist in a relatively undisturbed state due to their non-arable nature, and some have been preserved, but others remain unprotected or unrecognized. This lichen could serve as a valuable indicator of environmental quality in assessing such habitats.

A corollary is using *H. scalaris* absence to help interpret past human disturbance in sensitive habitats. For example, airports in eastern New York and western Massachusetts were built on sand plains, which lie in wide valleys and have easily worked and paved sandy soils. The original vegetation of these areas was pine barrens. Airports at Glens Falls and near Saratoga Springs, New York, and at Westfield, Massachusetts, were visited in 1979-1980 to survey the pine barrens vegetational remnants surrounding them. One of the organisms sought was *H. scalaris*. At all three sites, tracts of several hectares had apparently been cleared of original vegetation in the early part of this century, but a similar vegetation had grown around airfield edges in intervening decades (datable by conifer branch whorls). At each site, a deliberate, focused search was made for *H. scalaris* for at least 1 hour on 100+ *Pinus rigida* trunks. It was not found on any of the smaller *P. rigida* growing in these revegetating areas, even though most trees had mature bark plates. At the fringes, one or two much larger trees, obvious survivors from pre-development because of their age, were discovered with *H. scalaris* growing abundantly on their trunks. This suggests the slowness of *H. scalaris* recolonization after such drastic disturbance, and emphasizes the level of subtlety needed in interpreting pine barrens vegetational health: If *Pinus rigida* is abundant but *H. scalaris* is absent or occurs only on a very few large trees, then the present vegetation has probably developed following massive disturbance.

Human influences will undoubtedly impinge more heavily on *H. scalaris* as time passes. Timdal (1984) noted that this lichen is quite "toxitolerant" in Europe. In northeastern North America, it certainly persists in densely urbanized areas (as at Albany and Ithaca, New York), but most often on original trees, especially *Pinus*, spared because of their ornamental nature. As more edge habitats result from increased human clearing and building, it will be interesting to see how soon this lichen colonizes them. Mark R.D. Seaward observed that acid rainfall is causing bark acidification in England (pers. comm., August 1989); if pH 4.0 is a criterion for Oyster Lichen substrates, will the same atmospheric phenomenon expand substrate availability in America? Fire controls and paved borders of increasingly smaller plots in urban areas severely limit or eliminate natural fires that maintain the open-canopy vegetation so characteristic of *H. scalaris* habitats, and the charcoal on which it thrives. Timdal (letter, 17 August 1989) noted that *Hypocenomyce australis* Timdal, *H. castaneocinerea* (Räsänen) Timdal, *H. friesii, H. anthracophila*, and *H. scalaris* are all strongly associated with burned wood: "This genus must have required burnt substrata for millenia, and, I think, indicates the existence of forest fires for a very long period of time. Is burnt wood easily found in eastern North America today, and could modern forest fire prevention be a threat to *H. anthracophila* and *H. castaneocinerea*?" Fire suppression has seriously altered pine barrens vegetation at the Albany Pine Bush, New York (personal observations since 1973) and throughout the Northeast (Cryan, 1985). It is obvious that *H. scalaris* is adequately surviving on other substrates, but I have *never* encountered *H. anthracophila* on *P. rigida* during 13 years of field work in northeastern pine barrens. Brodo (1968) did find it frequently on Long Island, New York, on *P. rigida*. Likewise I have never seen *H. castaneocinerea*.

My explorations for this lichen have been influenced by human eye level, an early bias toward *Pinus rigida* substrates, and the happenstance of my peregrinations. There is also an eastern North American bias in collected and borrowed specimens. I was surprised at the paucity of specimens loaned from herbaria with large lichen collections (5 from FH, 6 from DUKE, 22 from US, 26 from NY, and 42 from MICH), indicating a rarely collected organism. As the scope of my search broadened from *Pinus* and *Acer* trunks in pine barrens, I was further surprised at the variety of its habitats and substrates, and that I had accumulated state records for New Hampshire and Virginia, the first records from 14 New York counties, and the first reports from 20 substrates. The common occurrence of this lichen on *Prunus serotina* has only recently been noticed and collections begun from this tree. The vital importance of detailed ecological and habitat notes on specimen labels in this kind of study was also apparent.

More collecting is needed to document the distribution of this lichen in the Western Hemisphere. Conifers are widespread in North America, occur in great variety, and are the longest-lived of our trees (Collingwood & Brush, 1984). Timdal (letter, 17 August 1989) observed that the Oyster Lichen is "remarkably scarce in oceanic parts of western Scandinavia." Is the apparent absence of *H. scalaris* from oceanic areas of northeastern Canada real, or has it been overlooked there? It grows abundantly on the coastal plain on Long Island, New York (Brodo, 1968, and personal collections), but is it also on Cape Cod, Massachusetts, and in the New Jersey Pine Barrens, where one would expect it? In studying my range map (Fig. 9), I noticed a seeming absence from fire-influenced pinelands in the Southeast which might reflect poor collecting. But a trip through Virginia, North Carolina, South Carolina, and northern Georgia disclosed no specimens of *H. scalaris* except from crests of the Blue Ridge Mountains. In the same niche on *Pinus palustris* in sandy piedmont pinelands, however, *Cladonia ravenelii* Tuck. was common everywhere. This lichen has squamules slightly smaller than those of *H. scalaris* and abundant soredia, and grows in much the same manner on the pines. It lacks podetia in most of its range, has a bluer-green color, and a distinctive chemistry (C-; didymic and thamnolic acids) (Richard C. Harris, letter, 28 November 1989). It is interesting that a lichen of a different family with the same thallus type and vegetative diaspore would have exploited the same niche regionally. Does *C. ravenelii* occur on pines throughout southeastern lowlands, and is *H. scalaris* confined to high elevations there, as it appears? The Oyster Lichen must occur throughout the West, on gymnosperms, at least. Will it colonize textured, charred, acidic wood (or *rocks*) in Yellowstone and other areas of recent widespread fires? Is it growing on the Bristlecone Pines (*Pinus aristata*), the oldest trees in the world? Has it colonized charred naturalized *Eucalyptus* in California as it has in Australia? Is it found on *Pinus* bark in Mexico and Central America, or on other islands in the Caribbean? Has it had time to colonize gymnosperms in American arboreta? Does it grow on old brick buildings here, as in Britain? Something is known of this lichen, but many exciting questions remain unanswered. I hope this paper will encourage collecting, identification, and appreciation of this beautiful small lichen. I welcome specimens from anywhere in this hemisphere to help compile a more complete distribution map at some future date.

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Appendix: North American Specimen Citations

For brevity, *specimens examined* are listed geographically only by *collector and number*, with herbaria indicated by standard acronyms. Two private herbaria are cited, the author's ("R.D.") and Claire K. Schmitt's ("SCHMITT"). Specimen numbers preceded by "*L*" and not including a collector's name (*e.g., L-3025*) are R. Dirig collections. The 210 MIN specimens were not seen, but are summarized from Clifford M. Wetmore's computer printout of *Hypocenomyce scalaris* material in that herbarium.

CANADA

QUEBEC: *Brodo et al. 19163A* (CANL); *Wong 3260* (CANL); *Brodo 5576* (CANL); *Sheard & Brodo 1438* (CANL); *Brodo & Fabiszewski 14804* (CANL).

ONTARIO: *Brodo 13648, 14589, 17097, 18758, 19472, 22751A* (CANL); *Cain 27146* (US); *L-1590, L-3013, L-3014* (NY); *L-3012* (R.D.); *Garton 15384* (CANL, 2 pkts.); *Henssen & Cain 14277* (CANL); *Imshaug 26271, 26726, 26962, 27185* (MICH); *Imshaug 25542* (CANL, US); *Wong 850, 1764, 1876, 1878, 2427, 2462, 2632, 2673, 2676, 2862A* (CANL); *Wong 1208, 1220* (CANL, MICH); 4 MIN specimens.

MANITOBA: *Scotter 3099* (CANL); 1 MIN specimen.

ALBERTA: *Ostafichuk 1072* (CANL); *Bird 28891* (CANL).

BRITISH COLUMBIA: *Noble 6495* (MIN, SCHMITT); *Noble 7394* (SCHMITT).

NORTHWEST TERRITORIES: *Scotter 1531, 1963, 2178, 2224, 2379, 2442, 2451, 2512, 2518, 2616, 3795, 8051, 8053* (CANL); *Thomson & Larsen 12322* (US); *Thomson & Larsen 14992* (CANL, MIN, US).

YUKON: *Scotter 19382* (CANL).

UNITED STATES

MAINE: *L-2205* (R.D., NY, US); *Willey s.n.* (US); 8 MIN specimens.

VERMONT: *Russell 12025* (MICH); *Thomson 9114* (MICH, US); *Willey s.n.* (US).

NEW HAMPSHIRE: *L-2202* (DUKE); *L-2203* (MICH); *L-2200, L-2204* (R.D., NY, US); *L-2199* (DUKE, NY); *L-2201* (MICH, NY).

MASSACHUSETTS: *L-1520* (NY); *L-1521, L-1522* (R.D.); *L-1523* (MIN); *L-1527* (R.D., NY, NYS); *L-1528* (R.D., NY, US); *L-1524* (MIN, NY); *L-1526* (US, NY); *L-1525* (US, NYS); *Gates 2391, 2430, 2738* (US); *Sherwood & Kneiper s.n.* (FH).

NEW JERSEY: *Nearing s.n.* (NY); *Nearing H-99* (MICH, NY); 8 MIN specimens.

NEW YORK: *ALBANY COUNTY*: *L-941, L-987, L-1399, L-1529, L-1533, L-1566, L-1567, L-1568, L-1570* (NY); *L-962* (R.D., NY, NYS, US, DUKE, CANL, MICH, MSC, FH, CUP, WIS); *L-717* (R.D., NY, NYS, US); *L-858, L-1400, L-1534* (R.D., NY, NYS); *L-995, L-1569* (R.D., NY); *L-832* (MIN, NY, MICH, OSLO); *L-986* (US); *L-1398, L-1405* (R.D.); *Milne 102* (NYS); *Schmitt 186, 1280* (SCHMITT). *BROOME COUNTY*: *L-1537, L-1538* (NY). *CHEMUNG COUNTY*: *L-1416, L-1417, L-1418, L-1420, L-1556* (NY); *L-1554* (R.D., NY); *L-1555* (US, NYS). *CHENANGO COUNTY*: *L-2185* (R.D., NY, NYS, US); *L-2186* (NY); *L-2187* (US); *L-2188* (R.D.). *CLINTON COUNTY*: *L-1539, L-1544, L-1545, L-1546* (NY); *L-1535, L-1540* (R.D., NY, NYS); *L-1541* (US); *L-1542* (R.D., NY); *L-1543* (NY, US); *COLUMBIA COUNTY*: *L-2996* (R.D.); *L-2997* (NY); *L-2998* (US). *DELAWARE COUNTY*: *L-1387, L-1388, L-1393, L-1394, L-1395, L-1396, L-1508* (R.D., NY, NYS); *L-1391, L-1392, L-1614*, (NY); *L-2376, L-2935, L-3094* (R.D.); *L-1510* (R.D., NY); *L-1389, L-1390* (R.D., NY, NYS, US, DUKE); *L-2485* (R.D., NY, US). *DUTCHESS COUNTY*: *L-1502, L-2999* (NY); *L-3000* (US); *Feeley 169* (NY). *ESSEX COUNTY*: *Lowe 4680, 4754a, 4763, 5028, 5030, 5066, 5069, 6013, 6060* (MICH); *Lowe 6044* (MICH [2 packets], MIN, NY, NYS). *GENESEE COUNTY*: *Muenscher & Muenscher 62* (CUP, NY). *JEFFERSON COUNTY*: *L-1415, L-3007* (NY); *L-3008* (R.D., NY). *MADISON COUNTY*: *Brodo s.n.* (NYS); *Brodo 5565* (CANL). *ONEIDA COUNTY*: *L-1419* (NY); *L-1559, L-1560* (R.D.); *L-1561* (DUKE); *L-1562* (US); *L-1563* (MIN, NY, NYS); *L-1564* (R.D., US, DUKE). *ONONDAGA COUNTY*: *L-3005* (NY); *Schmitt 761* (SCHMITT). *ORANGE COUNTY*: *Nearing H-94* (NY). *OSWEGO COUNTY*: *L-3006* (NY). *OTSEGO COUNTY*: *L-2993* (NY). *RENSSELAER COUNTY*: *L-1557* (US, NY); *L-1558* (R.D., NYS). *ROCKLAND COUNTY*: *Brako 2481* (NYS); *Fleming & Nearing s.n.* (NY); *Harris 13395* (NY); *Nearing s.n.* (NY). *SARATOGA COUNTY*: *L-1402, L-1571, L-1572* (NY); *L-1403* (DUKE, NY, NYS); *L-1409* (R.D., NY, NYS); *L-1411* (US, NY, NYS); *L-1573* (US, NY); *Schmitt 594* (SCHMITT). *SCHENECTADY COUNTY*: *L-1404* (R.D., NY, NYS); *L-1406* (R.D.); *L-1407* (NY). *SUFFOLK COUNTY*: *Brodo 1125, 3856* (NYS); *Brodo 1919* (US); *L-1531* (NY, US), *L-1532* (R.D., NY); *L-1530* (US, NYS); *L-1574, L-1576* (R.D.); *L-1575* (NY). *SULLIVAN COUNTY*: *L-1397* (R.D., NY, NYS); *L-2484* (R.D.). *TOMPKINS COUNTY*: *L-1483, L-1493, L-1515, L-1516, L-1547, L-2191, L-2212, L-2934, L-2939, L-2987, L-2988, L-2995, L-3009* (NY); *L-1517* (NY, NYS); *L-1518* (NY, US); *L-1548, L-1549* (R.D., NY); *L-1550* (MIN, NY); *L-1553* (R.D., NY, NYS, US); *L-1551* (R.D., NYS); *L-1552* (CANL, NY, US); *L-1827, L-1828* (R.D., NY, NYS). *ULSTER COUNTY*: *L-1322, L-1325* (R.D., NY); *L-1324* (NY, US); *L-1323* (R.D., NY, NYS, US, DUKE); *L-1923* (NY); *Harris 13490* (NY). *WARREN COUNTY*: *L-1408* (R.D.); *L-1410* (R.D., NY, NYS); *Everhart s.n.* (US); *Lowe 5643, 5916* (MICH); *Schmitt 819, 1269* (SCHMITT); *Schmitt 1520* (SCHMITT, NYS). *WASHINGTON COUNTY*: *Schmitt 147* (SCHMITT); *Schmitt 4115* (R.D.).

PENNSYLVANIA: *L-1536, L-3010, L-3011* (NY); *L-2183* (US); *L-2184* (R.D.); *L-2208, L-3051* (DUKE, NY, US); *L-2209* (R.D., NY, US); *L-2207* (MIN, NY); *L-2211* (US, NY); *L-2210* (MICH, NY, OSLO); *L-2927* (R.D., MICH, NY, US); 10 MIN specimens.

WEST VIRGINIA: *L-3063, L-3064* (R.D., NY); *L-3065* (R.D., NY, US); *L-3066* (US); *L-3067* (R.D.); 1 MIN specimen.

VIRGINIA: *L-3053, L-3059* (R.D., NY); *L-3056* (NY, US); *L-3057* (NY, CANL); *L-3054* (DUKE); *L-3055* (MIN); *L-3058* (R.D., NY, US).

NORTH CAROLINA: *L-3043* (R.D., NY).

TENNESSEE: 1 MIN specimen.

OHIO: *L-2929, L-2930* (R.D., NY); *L-2931* (R.D., NY, US, MICH); *Wetmore 6414* (MICH); 8 MIN specimens.

MICHIGAN: *Buck s.n.* (NY); *L-2182* (NY); *L-2780* (R.D., NY, US); *L-2781, L-2782* (R.D., NY); *L-2783* (DUKE); *Harris 10137, 10188, 10355, 11743, 12222, 12825* (MICH); *Harris 13104* (NY); *Imshaug 21379* (US); *Imshaug 27643, 27772* (MICH); *Nimke s.n.* (MICH); *Pinkley 23* (NY); *Shetler M182* (US); 24 MIN specimens.

MINNESOTA: *Wetmore 35782* (NY); *Thomson 16909* (US & another unrecorded herbarium); *Wetmore 22877* (FH, MICH); *Wetmore 39969* (unrecorded herbarium); 99 MIN specimens.

WISCONSIN: *Thomson, Lichenes Wisconsinenses Exsiccati 22* (CANL, US); 7 MIN specimens.

TEXAS: *Wetmore 18361* (MIN, US); 3 MIN specimens.

SOUTH DAKOTA: *Wetmore 10592* (US); 1 MIN specimen.

MONTANA: 1 MIN specimen.

COLORADO: *Shushan sl-8056* (MICH); *Wetmore l6208A* (US); 2 MIN specimens.

WYOMING: 1 MIN collection.

WASHINGTON: *Ryan 5695* (SCHMITT); 2 MIN specimens.

CALIFORNIA: *Hale 52153, 56252, 56551, 57418* (US); *Cole 1473* (US); *Wetmore 14674* (MICH); *Wetmore 14660* (CANL); *Herre s.n.* (MICH, NY); 19 MIN specimens.

ARIZONA: 6 MIN specimens.

CARIBBEAN

DOMINICAN REPUBLIC: *Buck 5292* (NY).

* * *

MYCOTAXON

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A TAXONOMIC REVISION OF THE GENUS CHEILYMENIA - 2.

CHEILYMENIA ASTEROPILA SPEC. NOV. AND CHEILYMENIA GEMELLA COMB. NOV.

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ABSTRACT: A new terrestrial species of the genus *Cheilymenia*, *Cheilymenia asteropila* spec. nov., based on three collections from Czechoslovakia, is described as a new taxon belonging to the section *Cheilymenia*. Type material of *Peziza stercorea* var. *gemella* Karsten (1869) and *Humaria stercorea* var. *glacialis* Rehm(1881) has been examined, and one new combination, *Cheilymenia gemella* (Karst.) comb.nov., is proposed. The detailed description, line drawings and SEM photomicrographs of *C. asteropila* accompany the paper.

Cheilymenia asteropila J.Moravec **spec. nov.**

Apothecia solitaria vix gregaria, 1-3 mm diam., leniter patellaria dein discoidea, usque explanata, sessilia, orbicularia, hymenio luteo vel laete vitellino, extus lutea, pilosa, setis longis, laete luteo-fuscis obsita. Excipulum externum textura globuloso-angulari. Excipulum internum (medulla) textura subintricata, usque intricata. Pili partim simplices, 200-680 (-800) x 20-40 µm, rigidi, recti, pallide luteo-fusci, crasse tunicati (tunica 2-3(-3.5)µm crassa), septati, apice acuti, basi radicati, lobato-furcati vel simplices, partim stellati, (asteropili), 2-5 ramosi, rami usque 200 µm non superantes, etiam pili superficiales, parvis, simplices vel sursum saepe bifurcati usque trifurcati, basi simplices. Asci 150-180 (200) x 10.5-12 µm, cylindracei, octospori, basi attenuati. Paraphyses filiformes, 3 µm crassae, apice non vel sensim dilatatae (usque 3.4-5 µm), luteolae. Ascosporae ellipsoideae, (13.5-) 14-16(-16.5) x (7.2-) 8-9(-9.4) µm, eguttulatae, perisporio minute verruculoso, verrucis cyanophilis, 0.1-0.6 µm diam. et 0.1-0.3(-0.5) µm altis, isolatis vel etiam breviter irregulariter elongatis et confluentibus (sed ordinatiore haud reticulata).
Habitat: terrestris.
1. Ad terram humidam nudam vel inter muscos et *Urtica dioica* in horto, Branžež prope Kněžmost, districtus Mladá Boleslav (Bohemia), 13. X. 1968 leg. Jiří Moravec.-Holotypus BRA, isotypus PRM et in herbario J.Mor. asservantur.

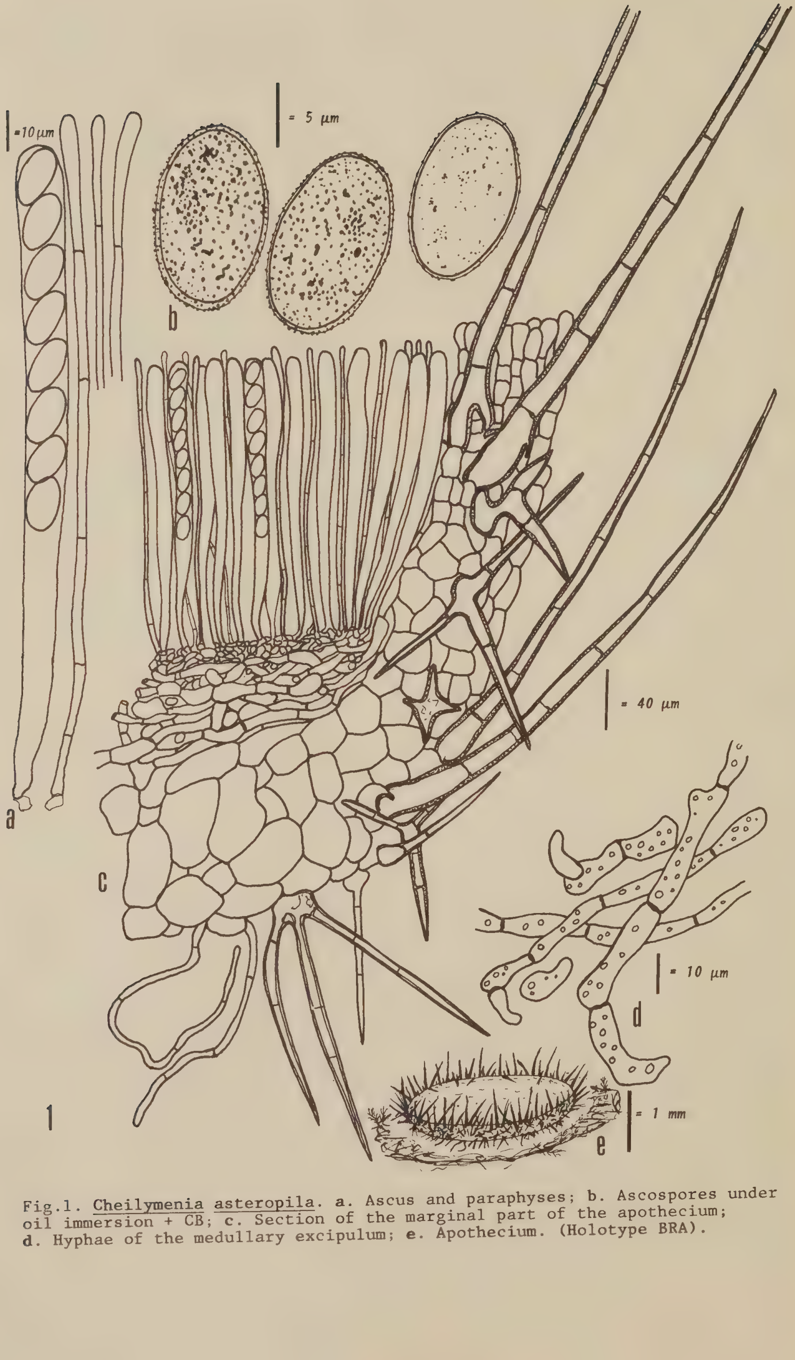
= 10 μm
a
= 5 μm
b
c
= 40 μm
= 10 μm
d
1
= 1 mm
e

Fig.1. Cheilymenia asteropila. **a**. Ascus and paraphyses; b. Ascospores under oil immersion + CB; **c**. Section of the marginal part of the apothecium; **d**. Hyphae of the medullary excipulum; **e**. Apothecium. (Holotype BRA).

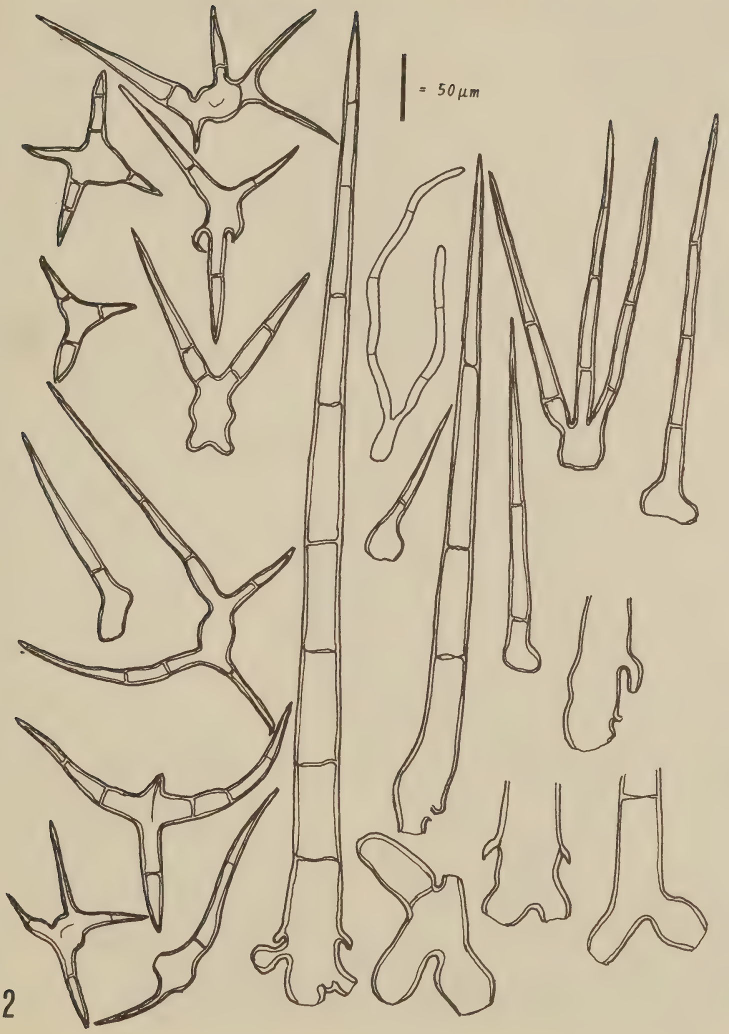

Fig. 2. Cheilymenia asteropila. Hairs. (Holotype BRA).

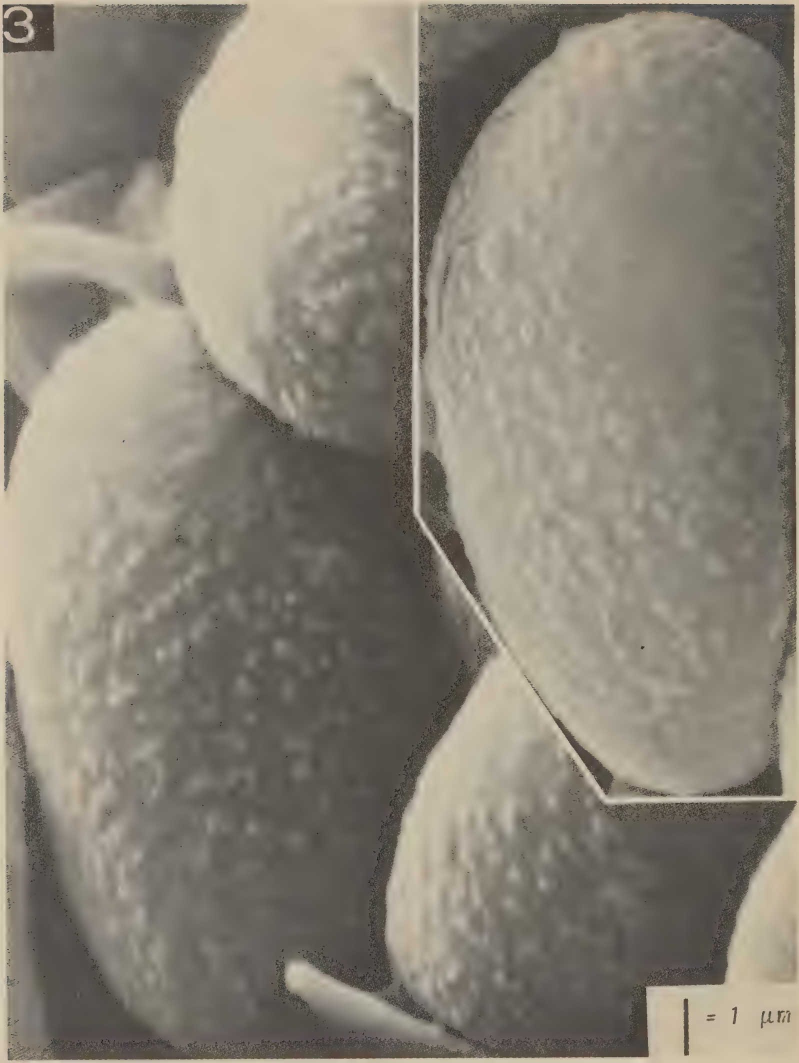

Fig 3. *Cheilymenia* *asteropila*.
SEM photomicrographs of ascospores.
(Holotype BRA).

2. Ad terram inter muscos viae silvaticae, Branžež-Zápudov prope Kněžmost, districtus Mladá Boleslav (Bohemia), 13. X. 1968 leg. Jiří Moravec.- Paratypus BRA.
3. Ad terram prope carbonario in silva, monte Kozákov (720 m) non procul Turnov (Bohemia borealis), 3. XI. 1968 leg. Jiří Moravec.- Paratypus BRA, J.Mor.

Apothecia scattered or occasionally aggregated, sessile, shallow-cupulate to discoid, fleshy, hymenium bright yellow to light egg-yellow, external surface yellowish, covered with yellow to yellow-brown hairs, which are conspicuously long near the margin of apothecia. Hairs of several types: Rooting hairs 100-600(-800) x 20-40 µm, straight, rigid, yellow to yellow-brown, pointed above, thick-walled, (walls 2-3(-3.5) µm thick), septate, often with a wide, lobed, or rooting base, or with an elongate, truncate wide base, occasionally with only small rounded roots in the upper part of the base; excipular hairs often stellate, 2-5 rayed, with arms up to 200 µm long, septate, walls 1-3 µm thick - these stellate hairs are distributed on the whole external surface including the marginal zone; besides the stellate hairs, copious, very thin, acute, simple or often dichotomous hairs are also present and they are mixed with thin-walled, hyaline, flexuous, septate hyphae towards the base of apothecia. Ectal excipulum a textura globulosa-angularis to prismatica, composed of 1-4 rows of globose to mostly angular cells; the cells 15-65 µm diam., grading to smaller angular to prismatic cells arranged in vertical rows towards the margin of the apothecia, often clavate and blunt above, 8-14 µm thick, forming a marginal collar. Medullary excipulum composed of irregularly arranged hyphae, which are 4-12 µm thick,septate, occasionally mixed with elongated subglobose to lobed cells forming a textura subintricata to intricata. Asci 150-180 (-220) x 10.5-12 µm, cylindrical, eight-spored, non-amyloid, distinctly narrower at the base. Ascospores ellipsoid, (13.5-) 14-16(-16.5) x (7.2-) 8-9(-9.4) µm, mostly 15 x 8.6 µm, without guttules, with a yellow refractive colour when stained with cotton blue in lactic acid (CB), bearing a loosening perisporium covered by densely arranged, fine, isolated, cyanophilic warts and short, irregular, occasionally connected crests 0.1-0.6 µm diam. and 0.1-0.3(-0.5) µm high. Paraphyses filiform, straight, 3 µm thick with apex slightly enlarged to 3.5-5 µm diam., containing yellow pigment.
Habitat: On soil.
Material examined:

1. Czechoslovakia, Bohemia, district of Mladá Boleslav, Branžež near Kněžmost, on moist soil and on soil amongst low moss under Urtica dioica in a garden, 13. X. 1968 leg. Jiří Moravec.-Holotype BRA, Isotype PRM and J.Mor.

2. Czechoslovakia, Bohemia, district of Mladá Boleslav, Branžež-Zápudov near Kněžmost, on moist mossy soil on edge of a path in mixed forest, 13. X. 1968 leg. Jiří Moravec.- Paratype BRA.

3. Czechoslovakia, Bohemia borealis, Mt. Kozákov (720 m.) near Turnov, on soil near burnt place, 13. XI. 1968 leg. Jiří Moravec.- Paratype BRA and J.Mor.

The mature ascospores of C. asteropila measure usually 15 x 8.6 µm, and, the size of ascospores, which are regularly developed in 8-spored asci, does not exceed 16.5 x 10 µm. However, the ascospore size may reach exceptionally up to 19.5 x 10.5 µm in asci with a reduced number of mature ascospores (in 4-6-spored asci, which occasionally occur in the third collection from Turnov). In fact, the ascospore size of C. asteropila varies only slightly as the larger size of ascospores, which are exceptionally developed in asci with a reduced number of mature ascospores, must be considered to be a size of anomalous ascospores.

C. asteropila is a remarkable species characterized by stellate excipular hairs, which are similar to those of Cheilymenia ciliata (Bull. ex St. Amans) Maas Geesteranus (= Cheilymenia stercorea (Wigg. ex S.F.Gray) Boud.). Together with this type species of the genus, also C. asteropila is referred to the section Cheilymenia in a new classification of the genus (J.Moravec 1990).

However, C. asteropila differs from C. ciliata in having much smaller ascospores with the verruculose perisporium, yellow to light egg-yellow apothecia, and terrestrial habitat.

C. ciliata is a strictly coprophilous species, distinguished by the habitat, orange-reddish apothecia, and larger, smooth spores. According to my examination of many collections, the ascospores of C. ciliata measure 18-23 x 9-12 µm, and, their perisporium is almost smooth with only secondary wrinkling and patches when stained with CB. The detailed descriptions of species referred to the section Cheilymenia will be given separately.

The taxonomy of C. ciliata was discussed and taxonomic problems explained by Maas Geesteranus (1969), and I have fully accepted the results given by him.

Scutellinia crucipila (Cooke et Phill.in Cooke) J.Mor. (= Cheilymenia crucipila (Cooke et Phill. in Cooke) Dennis), which also grows on soil and possesses excipular stellate hairs, differs clearly from C. asteropila in having much shorter, inconspicuous rooting hairs (up to 300 µm long), and bright orange, orange-red to scarlet hymenium. Moreover, the ascospores of S. crucipila are longer, bearing the perisporium covered by larger warts and crests, which are usually elongated on the ascospore poles. Also, the yellow refractive colour of ascospores when stained with CB, which is a feature of species of the genus Cheilymenia, is absent in ascospores of C. crucipila.

The examination of type material of Peziza stercorea Pers. var. gemella Karsten (1869) revealed that five collections, which are deposited in H, represent two different fungi. The type material consists of five packets containing specimens collected on horse dung in Mustiala, Finland. Three of these packets (including one labelled "817 Fungi Fenniae exsiccati") contain apothecia of Cheilymenia coprinaria (Cooke) Boud. (determined by me). Two remaining packets contain apothecia of a species, which is not identical with any other species of the genus Cheilymenia. Therefore, I have selected the collection labelled H 2465 as holotype and H 2502 as paratype of Peziza stercorea Pers. var. gemella Karst. A new combination is proposed:

Cheilymenia gemella (Karst.) J.Moravec **comb. nov.**
Basionym: *Peziza stercorea* Pers. var. *gemella* Karsten, Not. Sällsk. Faun.Fl. Fenn. Föhr. 10:126, 1868; Mycologia Fennica I. Discomycetes p. 71, Helsingfors, (1871). (ut *Peziza stercorea* **gemella* Karst.).
G. gemella is a species similar to *C. coprinaria*. The apothecia of *C. gemella* are considerably larger(up to 8 mm), and the excipular hairs are not stellate. The species is quite different from *C. ciliata* and *C. asteropila*. It should be noted that *C. gemella* differs from the type of *C. coprinaria* in having smaller ascospores, and narrower, long,often flexuous, copious rooting hairs with simpler base. The ascospores bear a smooth perisporium. The detailed description and drawings will be given in a separate paper.

The type material of *Humaria stercorea* Pers.var. *glacialis* Rehm (1881) has also been examined. A few apothecia on cow dung represent a coprophilous species of *Cheilymenia*. It is distinguished for its hairs, which are simple, only rarely septate or not septate, with a simple or widely bifurcate base. Stellate hairs are not present. Instead of them, only simple, short excipular hairs with a wide, irregularly bulbous base are scattered on the external surface towards the base of apothecia. Ascospores of a size 16-24 x 9-12 µm, bearing a smooth perisporium, similar to ascospores of *C. ciliata*. The type material is scanty and it is rather difficult to decide if it is a form of *C. ciliata* or if it represents a separate species. Despite the absence of the stellate hairs, this taxon seems to be close to *C. ciliata*, and clearly differs from *C. coprinaria*.
According to Rehm (1895), *C. stercorea* var. *gemella* and var. *glacialis* were identical with *Humaria alpina* Fuck. (= *H. stercorea* (Wigg.ex S.F.Gray) Fuck.var. *aurantiaco-flava* Fuck.) collected also on cow dung. However, *H. alpina* , distinguished for its stellate apothecial hairs,is a synonym of *C. ciliata* as has been stated by Rifai (1968).
Type material of *Peziza scubalonta* Cooke et Gerard apud Cooke has also been examined. I can confirm the identity of this taxon with *C. ciliata* as has been proved by Denison (1964).
All these coprophilous taxa mentioned above are quite distinct from *C. asteropila*.

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REVISED CLASSIFICATION OF ARBUSCULAR MYCORRHIZAL FUNGI (ZYGOMYCETES): A NEW ORDER, GLOMALES, TWO NEW SUBORDERS, GLOMINEAE AND GIGASPORINEAE, AND TWO NEW FAMILIES, ACAULOSPORACEAE AND GIGASPORACEAE, WITH AN EMENDATION OF GLOMACEAE.

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ABSTRACT

A new order, Glomales, is proposed to include all soil-borne fungi which form arbuscules in obligate mutualistic associations with terrestrial plants. The proposed suborder, Glomineae, consists of the type family Glomaceae and Acaulosporaceae fam. nov. *Glomus* and *Sclerocystis* are genera in the Glomaceae characterized by "chlamydospores" borne singly, in aggregates, or in compact sporocarps on one or more cylindrical to flared subtending hyphae. *Acaulospora* and *Entrophospora* in the Acaulosporaceae are historically equivalent sister groups. Species in these genera are distinguished by "chlamydospores" formed laterally from or within a hypha terminating in a sporiferous saccule. Intermediate species in Acaulosporaceae show a progressive transformation from spores resembling *Glomus* to those which are uniquely sessile. Gigasporineae subord. nov. is proposed to include Gigasporaceae fam. nov. Both genera in this family, *Gigaspora* and *Scutellispora*, produce "azygospores" borne terminally on a sporogenous cell. Taxa in Gigasporineae produce extraradical auxiliary cells and no intraradical vesicles, whereas taxa in Glomineae form intraradical vesicles. The Endogonales was emended to contain only one family, Endogonaceae, with a single genus, *Endogone*. A key to supraspecific taxa in Glomales is provided.

Key words: Endogonales, Endogonaceae, vesicular-arbuscular mycorrhizal fungi, VAM fungi.

INTRODUCTION

Until recently, the order Endogonales (Zygomycotina) has consisted of only one family, the Endogonaceae (Benjamin, 1979; Morton, 1988). Six genera (*Acaulospora* Gerdemann & Trappe emend. Berch, *Entrophospora* Ames & Schneider, *Gigaspora* Gerdemann & Trappe, *Glomus* Tulasne & Tulasne, *Sclerocystis* Berkeley & Broome, and *Scutellispora* Walker & Sanders) were included whose members formed an arbuscular mutualistic symbiosis with many terrestrial plant families (Trappe, 1987) and one genus (*Endogone* Link:Fr.) whose members were saprobic (Gerdemann and Trappe, 1974) or formed putative ectomycorrhizal associations (Chu-Chou and Grace, 1979; Fassi et al., 1969). The historical reasons for combining this heterogeneous assemblage in the same order have been documented by Berch (1986b), Gerdemann and Trappe (1974; 1975), Morton (1988) and Walker (1987) and they will not be reviewed again here. These and other workers have recognized the artificiality of this classification, but the taxonomic relationships within and between levels of the geneological hierarchy were too nebulous to make significant changes.

Pirozynski and Dalpé (1989) separated *Glomus* and *Sclerocystis* into a separate family, the Glomaceae. Their rationale appeared to rest on paleontological evidence spanning 400 million years of fossilized intraradical spores resembling extant analogues in *Glomus* and *Sclerocystis* (Pirozynski and Dalpé, 1989; Stubblefield and Taylor, 1988). The move was valid, but it did not provide neontological arguments of hierarchial relationships among extant taxa. Important taxonomic comparisons not discussed were: (i) the extent of morphological diversity within extant taxa, (ii) phylogenetic relationships between fossilized and extant taxa, and (iii) phylogenetic affinities between Glomaceae and other arbuscular fungal taxa.

The fossil record has been invaluable in establishing early origin of a putative symbiosis (Stubblefield et al., 1987) and a measure of evolutionary rate of change in some members of the Glomaceae (Pirozynski and Dalpé, 1989; Stubblefield and Taylor, 1988). Described fossils, however, represent less than 5% of total morphological diversity in the Glomaceae and show nothing of other arbuscular genera. Revision of the present classification to make hierarchial groupings more "natural", then, must be predicated on character analyses of extant species.

A natural classification can be organized along different guidelines. Cain (1962), for example, considers that characters which have the greatest physiological importance in an organism's life cycle reflect hierarchial processes in nature. Others deem that classification should be interpretable within an evolutionary context (Cronquist, 1988; Eldredge and Cracraft, 1980). Often, this means grouping taxa which are related by descent from a common ancestor (e.g. monophyly). Both criteria are met in this revision.

Morton (1990a) used all available data on selected morphological characters of somatic (hyphae, arbuscules, vesicles) and reproductive (resting spores) stages of known arbuscular species to hypothesize explicit geneological trends. Cladistic analysis and a phylogenetic reconstruction were based on an evolutionary species definition (Wiley, 1978): clonal populations which together maintained a distinct morphological identity from other clonal assemblages and which had the same evolutionary role and tendencies. A revised species concept to accommodate phenotypic variability as well as historical and contemporary evolutionary processes is elaborated by Morton (1990b).

In this paper, classification of the Endogonales (*sensu lato*) is revised to more accurately arrange groups of arbuscular fungi according to patterns of common descent. It is based in part on results of Morton (1990a), with additional considerations of spore ontogeny and modes of spore germination. Interpretations of putative mechanisms of speciation and macro- and microevolutionary processes for the revised classification are examined in greater detail by Morton (1990b). Spelling of scientific names in this paper are in accordance with recommendations of Almeida (1989).

NEW TAXA AND EMENDATIONS

Endogonales Moreau, 1953 (*Encycl. Mycol.* **23**: 1231) ex R. K. Benjamin, 1979 (*in* Kendrick, *The Whole Fungus*, p. 599) emend Morton & Benny

Fungi mostly hypogeous or rarely epigeous; saprobic and free-living, sometimes forming associations resembling those of ectomycorrhizae. Somatic hyphae coenocytic; septa sometimes produced which contain micropores. Sexual reproduction by nearly globose or ovoid zygospores most often formed in sporocarps. Zygospores formed on apposed suspensors which are nearly equal or unequal. Sexual and somatic hyphae similar.

Endogonaceae Paoletti, 1889 (*in* Saccardo, *Sylloge Fungorum* **8**: 905) emend Morton et Benny

A single family, with the characteristics of the order, is recognized.

Type genus: *Endogone* Link:Fr.

The sporocarpic habit appears to be a convergent character among many disparate taxa in the Zygomycetes. Three Zygomycete orders contain sporocarpic taxa: Mucorales [*Modicella* Kanouse (Mortierellaceae--Trappe and Schenck, 1982; Benny et al., 1987)]; Endogonales [*Endogone* (Endogonaceae--Gerdemann and Trappe, 1974; Benjamin, 1979)], and Glomales [*Glomus, Sclerocystis* (Glomaceae--Pirozynski and Dalpé, 1989)]. However, the sporocarps of *Endogone* species bear only superficial morphological similarity to those of arbuscular fungi. Zygospores most often develop in *Endogone* sporocarps whereas only putative asexual chlamydospores form in *Glomus* and *Sclerocystis* sporocarps (Gerdemann and Trappe, 1974; Morton, 1988). Similarity between the pre-germination chamber formed in the zygospore wall of *E. pisiformis* and "germination chambers" or "germination shields" in *Acaulospora* and *Scutellispora*, respectively, also has been used to suggest phylogenetic relatedness among taxa (Berch and Fortin, 1982), but these characters are not homologous (Morton, 1990a). Cladistic analysis (Morton, 1990a) clearly indicates that sporocarp development was a convergent character state in *Endogone*. No other characters unite members of this genus with arbuscular mycorrhizal fungi.

Phylogenetic affinities are too obscure to confidently place *Endogone* in another family within the Zygomycetes. The only taxonomic solution at this time is to maintain *Endogone* as the sole genus in the Endogonaceae (Endogonales). Berch (1986b) suggests that enough heterogeneity exists to warrant possible generic distinctions. This problem is beyond the scope of this paper, and it will need to be addressed by other workers.

Glomales Morton et Benny, **ord. nov.**

Fungi plerumque hypogaei, raro epigaei; endomycorrhizas arbusculis in radicibus formantes et in symbiose cum plantis viventes. Hyphae somaticae coenocyticae. Reproductio sexualis raro. Reproductio asexualis a sporis chlamydosporis vel azygosporis simulantibus. Sporae plerumque singulatim efformatae; alterne, sporae gregatum vel in sporocarpiae compactae efformatae.

Fungi mostly hypogeous, sometimes epigeous; forming arbuscular endomycorrhizae in mutualistic symbiosis with living plants. Somatic hyphae generally coenocytic. Sexual reproduction rare. Asexual reproduction by spores resembling chlamydospores and azygospores. Spores formed singly, but also in aggregates or in sporocarps.

Familia typica: Glomaceae Pirozynski & Dalpé

All fungi in this order grow and reproduce in an "adaptive zone" (Van Valen, 1976), or collective niche (Simpson, 1961), where carbon is acquired obligately from their host plants via intraradical dichotomously-branched arbuscules. In return, the fungus aids in uptake of water and essential nutrients for benefit to the host (Harley and Smith, 1983). In the physical and physiological interaction between host and fungal partners, the arbuscule is central to nutrient interchange (Bonfante-Fasolo, 1984; Bowen, 1987). The importance of the endomycorrhizal association in both plant and fungal evolution is discussed by Pirozynski and Malloch (1975), Malloch (1987); Malloch et al. (1980), Pirozynski (1981) and Morton (1990b). Structure and function of the arbuscule clearly unites members of the Glomales into a monophyletic group (Morton, 1990a) (Fig. 1).

Speciation most likely occurred as an adaptive shift from a saprobic to mutualistic association (Morton, 1990b). Many of the characteristics of spore development, spore phenotype, and spore germination are unique to the Glomales and not readily interpretable within classification systems of other zygomycetous groups. If the Glomales is perceived as an evolutionary cul-de-sac (Malloch, 1987) bounded by a unique adaptive zone, then these complications are a source of enlightenment rather than frustration.

Glomineae Morton et Benny, **subord. nov.**

Arbuscules vesicaeque solum in mycorrhizarum radices efformatae. Chlamydosporae terminales, intercalares, vel laterales ex hyphis fertilis. Cellulae auxiliares nihil efformatae.

Arbuscules and vesicles formed in mycorrhizal roots. "Chlamydospores" produced terminally, intercalarily, and laterally from the fertile hyphae. Auxiliary cells not formed.

The magnitude of the morphological differences in spore development and organization, as well as mycorrhizal anatomy, is large enough between Glomineae and Gigasporineae to justify their status as suborders (Fig. 1). Taxa in Glomineae form intraradical vesicles in addition to arbuscules in mycorrhizal roots. Hence, they may fit the acronym "VAM" in describing mycorrhizal morphology. Spores resemble "chlamydospores" in the Glomaceae. Those in the Acaulosporaceae traditionally have been called "azygospores" (Gerdemann and Trappe, 1974). However, morphological divergence in spore development progresses step-wise from Glomaceae to Acaulosporaceae via transition species. *Acaulospora appendicula* Spain, Sieverding & Schenck is the most obvious of these species (Morton, 1990a). This dimorphic fungus has many characters in common with species in Glomaceae (Fig. 13): (i) "chlamydospores" formed on a subtending hypha (although it branches from the neck of a sporiferous saccule); (ii) an outer wall evanescent on older spores that is discontinous with the subtending hyphal wall; (iii) more than one structural wall (two ornamented unit walls), one of which is continuous with the hyphal wall; and (iv) separate and morphologically distinct "chlamydospores" formed singly (Schenck et. al., 1984; Morton, unpubl.).

Glomaceae Pirozynski & Dalpé, 1989 (*Symbiosis* **7**: 19)

Type genus: *Glomus* Tul. & Tul., 1845 (*Giorn. Bot. Ital.* **2** (Pt. 1): 63)

Other taxon: *Sclerocystis* Berk. & Broome, 1875 (*J. Linn. Soc. London* **14**: 137)

The fossil record links a putative ancestor for the Glomales with modern species in *Glomus* and *Sclerocystis* (Pirozynski and Dalpé, 1989). Most stages of spore development, from those formed singly on a subtending hypha to those formed in compact sporocarps, are represented at least minimally in fossilized remains of plant roots (Stubblefield and Taylor, 1988). Chronologically, these fossil specimens indicate that glomuslike spores were formed as early as the Devonian (Pirozynski and Dalpé, 1989, Stubblefield and Taylor, 1988) and that arbuscular development occurred in plants at least by the Triassic Period (Stubblefield et al., 1987). Extant species (*G. aggregatum* Schenck & Smith emend. Koske, *G. intraradix* Schenck & Smith) whose spores are similar morphologically to those of fossil specimens have a propensity to form numerous spores within mycorrhizal roots, and it is these intraradical propagules which appear to have been preserved. The majority of species in *Glomus* and *Sclerocystis* do not form intraradical spores (Morton, 1988), so their absence in the fossil record is not a surprise. Spores outside the protected environment of plant roots are less likely to resist microbial decomposition long enough to become fossilized, particularly in oxygenated soils or those with high organic matter. Sporocarpic forms in the fossil record superficially resemble taxa currently placed in *Sclerocystis*. Many of these species are being transferred to *Glomus*, with the exception of *Sclerocystis coremioides* Berk. & Broome (Almeida and Schenck, pers. commun.).

A number of characters (Table 1) distinguish extant members of the Glomaceae from those in other proposed families of arbuscular fungi. The term "chlamydospore" still is retained to describe resting asexual spores in the Glomaceae, although their similarities to analagous structures in non-arbuscular zygomycetous fungi is equivocal (Morton, 1988).

The sporocarpic habit, defined here as spores embedded within compact intertwining hyphae or around a central hyphal plexus (Fig. 2), is found only in the Glomaceae. Berch (1986a) emended the description of *Acaulospora* to include the sporocarpic habit, but the dense aggregates of spores formed by several species (*A. myriocarpa* Schenck, Sieverding & Schenck and *A. sporocarpia* Berch) are indicative of a more plesiomorphic stage in an evolutionary transition to sporocarp development (Morton, 1990a). The sporocarpic habit is a highly variable character in some *Glomus* species (Morton, 1988) and hence must be interpreted with caution. Indications are that species forming highly organized sporocarps may be more stable in pot culture, but more experimental studies are needed for verification.

Spore wall structure in the Glomaceae has a number of unique characteristics (Table 1). Inner walls are few in number (rarely more than one is present), and they usually are membranous. One interpretational problem is that the membranous phenotype is not always consistent. It ranges from very thin (membranous) to thick (appearing coriaceous) to semi-rigid (breaking sharply with only slight pressure to the spore) in spores of some species (Koske and Walker, 1986; Morton, 1985). Spores of most members of Glomaceae have only one wall group (Figs. 2-10) when they are broken *gently* in mountants such as lactophenol or polyvinyl alcohol-lactic

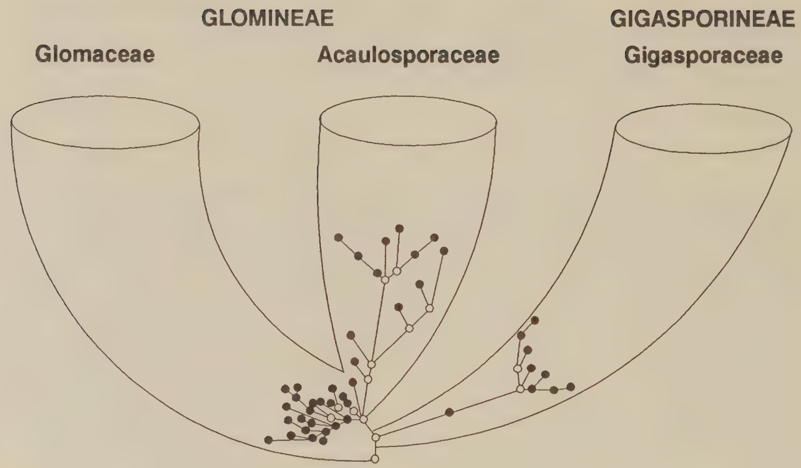

Fig. 1. Phylogenetic patterns of taxa confirmed as arbuscular mycorrhizal symbionts (from Morton, 1990a) which distinguish suborders (Glomineae and Gigasporineae) and families (Glomaceae, Acaulosporaceae, and Gigasporaceae) of the Glomales. Solid circles = extant species; hollow circles = hypothetical ancestors. The length of each line connecting circles indicates extent of morphological change.

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acid-glycerin (PVLG) (Hall, 1984). Two wall groups may be present in spores of *Glomus* species having one or more flexible inner walls, but such distinctions are equivocal (Fig. 8). The extent to which wall groups reflect temporally distinct stages in spore wall development, as observed in the Acaulosporaceae and Gigasporaceae, has yet to be determined.

Ontogeny of spores in the Glomaceae has received little study. In species with a single structural laminated wall, spores form by expansion of the sporophore tip and then gradual thickening of the structural spore wall (Morton, unpubl.). In spores of *G. intaradix*, which have a more complex wall structure (Fig. 29), temporal progression of the two outer walls could not be separated (Fig. 9). The inner laminated wall formed last (Fig. 10), but no chemical markers (such as a reaction in Melzer's reagent) specified when spores were fully mature. Considerable more work is needed to clarify ontogenetic sequences in *Glomus* species with more diverse spore wall structures.

Most taxa in Glomaceae appear to have the potential to form vesicles (Figs. 30-31), although the rate and pattern of vesicle development in mycorrhizal roots appears to vary among host species and with changing environmental conditions (Morton, 1985; Tommerup, 1984). In some *Glomus* species, vesicles appear to be transformed into thick-walled spores (Fig. 31) indistinguishable from extraradical spores (Morton, 1985). In other species, neither arbuscules or vesicles have been confirmed because intraradical structures do not stain easily (Morton, 1988).

Evidence so far suggests that emergence of the germ tube through the subtending hypha is the most common mode of spore germination. Direct germination through the spore wall has been documented for several species (Hall, 1977; Walker and

Table 1. Morphological characters or character complexes unique to each family in Glomales [see Morton (1988) for a more complete explanation of each feature, except where noted otherwise].

Glomaceae

Chlamydospore-like resting structures are borne terminally on one or more subtending hyphae (Figs. 2-10).

Compact sporocarps with spores embedded in an unorganized (Fig. 3) to highly organized hyphal matrix (Fig. 2) are formed by some species.

Different types of multiple outer walls (Figs. 5-6) account for most diversity in spore wall structure. Distinct outer walls include the expanding wall, a mucilagenous evanescent outer wall (Figs. 7, 10) which stains dextrinoid in Melzer's reagent (Morton, 1989), and tortuose hyphae over the spore surface (Figs. 9-10).

At least one structural wall of the spore wall is continuous with a wall of the subtending hypha (Figs. 2-10)

Inner flexible spore walls rarely react with Melzer's reagent (Fig. 8); those that do are atypically slow and diffuse.

Spore contents are isolated from the sporophore by a variety of mechanisms: an amorphous plug, a curved septum (Fig. 7), an inner flexible wall (Fig. 8), or thickening of the structural wall (Fig. 10).

Spores of most species germinate by emergence of the germ tube through the subtending hypha (Fig. 4).

Mycorrhizal vesicles are intraradical mostly, with the potential to become thick-walled spores in some species (Figs. 30-31).

Acaulosporaceae

Spores develop from (Fig. 11) or within (Fig. 12) the neck of a sporiferous saccule.

Sporiferous saccules and attached spores usually are borne singly (Figs. 11-12), but occasionally they form aggregates.

Spores rarely have more than one structural wall, the surface of which ranges from smooth (Figs. 14-15) to highly ornamented (Figs. 16-18).

Spores have a minimum of one flexible wall (Fig. 13), but usually two or more are present (Figs. 14-19).

Number and type of inner flexible walls account for most diversity in spore wall structure. Distinct wall types include the semi-rigid unit wall and the "beaded" membranous wall (Figs. 14-15); the latter complexing with either an innermost membranous (Figs. 18-19) or amorphous wall (Figs. 14-15).

Spore wall material appears to seal the opening to the neck of the sporiferous saccule (Fig. 18).

Spore germination occurs with a germ tube emerging from ephemeral "germination compartments" (Mosse, 1970) between a semi-rigid unit wall and a beaded membranous wall (Fig. 19).

Mycorrhizal vesicles are intraradical (Figs. 32-33); they do not appear to have the potential to become thick-walled spores.

Gigasporaceae

Spores are borne terminally on a sporogenous cell (Spain et al., 1989) (Figs. 20-26).

Spores generally are large, usually exceeding 300 μm in diameter.

Spores have, as a minimum, a thin outer unit wall tightly adherent with a laminated structural wall (Figs. 20, 22); both walls appear to be continuous with the walls of the sporogenous cell (Gibson et al., 1987).

Flexible inner walls form an "endospore"; with number and type of walls accounting for most structural diversity (Figs. 24-25). Distinct wall types include the coriaceous wall alone or complexed with either a membranous (Fig. 28) or amorphous innermost wall (Figs. 23, 25).

Spore contents are isolated from the sporogenous cell by what appears to be a thin septum (Fig. 26) not discernible in all spores.

Germ tubes arise from a warty germinal wall (Spain et al., 1989) (Fig. 27) or a complex germination shield (Figs. 25, 28).

Mycorrhizae is arbuscular (Figs. 34-35) with thin-walled auxiliary cells (Fig. 35) produced in soil; cell surfaces range from smooth to highly ornamented.

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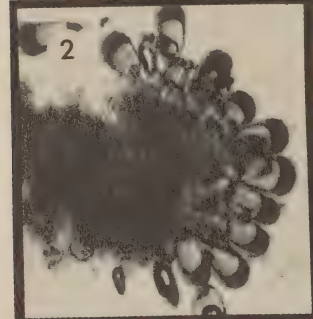

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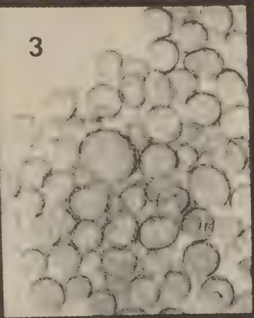

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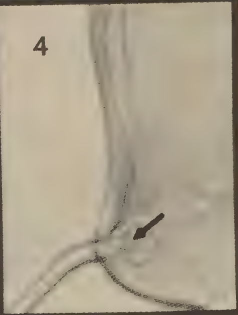

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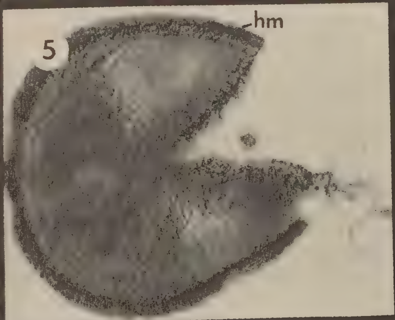

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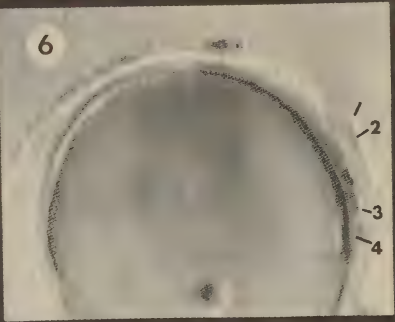

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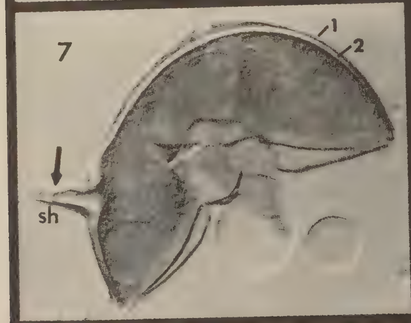

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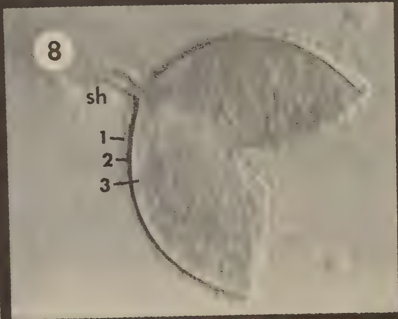

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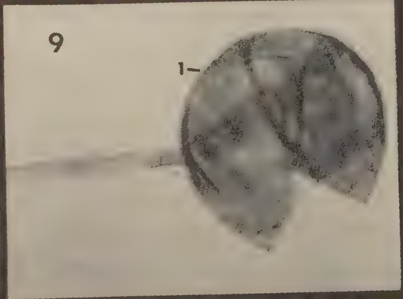

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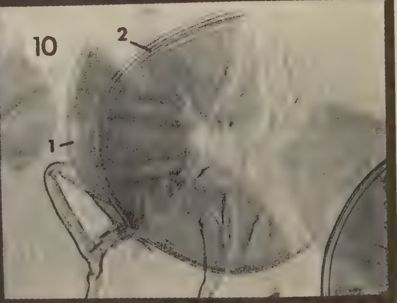


Rhodes, 1981), but greater documentation is needed because of its putative evolutionary significance in defining divergent lineages.

Acaulosporaceae Morton et Benny, **fam. nov.**

Chlamydosporae gestae a lateribus in vel intra hypha infundibuliformis vel cylindracea in sacculo sporangifere globoso prope terminatae. Chlamydosporae singulatim gregatimve in terra efformatae; post dehiscentia ab collo sacculi sessiles; globosae a irregulare. Chlamydosporae parietibus saltem triformibus: pariete exteriore evanida; pariete lammellata vel monas; parieteque interiore flexile e hyaline. Endomycorrhizae cum vesicules et arbuscules in radicibus; vesiculae ellipsoidae vel irregulares vel lobatae.

"Chlamydospores" formed laterally on or within a cylindrical or funnel-shaped hypha terminating in a sporiferous saccule. Chlamydospores borne singly or occasionally in loose aggregates in soil; sessile after detachment from the saccule neck. Chlamydospores with at least three wall types: an evanescent outer wall, a unit or laminated structural wall, and an inner hyaline flexible wall. Endomycorrhizae with intraradical arbuscules and vesicles; vesicles ellipsoid to irregular to lobed.

Type genus: *Acaulospora* Gerd. & Trappe, 1974 (*Mycologia Mem.* 5: 31) emend. Berch, 1986 (*Mycotaxon* 23: 31).

Other taxon: *Entrophospora* Ames & Schneider, 1979 (*Mycotaxon* 8:347).

The fossil record holds no clues of the temporal origin or rate of evolutionary change in Acaulosporaceae. This blank geological slate may be attributed more to the absence of sporulation by these fungi in plant roots and poor preservation rather than to recent ancestry.

In *Acaulospora*, species follow a progressive transformation of spores with many *Glomus* characters (e.g. *A. appendicula*) to spores with characters unique to the Acaulosporaceae (Table 1). The branching subtending hypha (of *A. appendicula*) (Fig. 13) appears to be reduced in an evolutionary transition series (Morton, 1990a) from a short "pedicel" in *A. myriocarpa* Spain, Sieverding & Schenck and *A. sporocarpia* Berch to a "collar" in *A. nicolsonii* Walker, Reed & Sanders and *A. spinosa* Walker & Trappe (Fig. 18) and finally to slight thickening between spore and saccule neck. The outer spore wall also is modified from an origin independent of the saccule neck in *A. appendicula* (Fig. 13) to one where it is continuous with the saccule neck (Fig. 11). The formation of spores within the saccule neck (Fig. 12) appears to be a discrete evolutionary advancement canalized in all *Entrophospora* species.

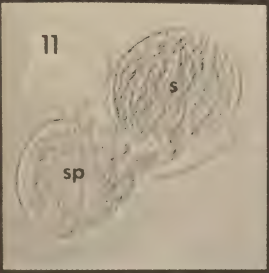
Figs. 2-10. "Chlamydospores" of species in the Glomaceae, mounted in polyvinyl-lactic acid-glycerin (PVLG) and photographed using Nomarski interference optics. Wall numbers correspond to those on murographs depicted in Fig. 29. **2.** *Sclerocystis clavispora* Trappe sporocarp (in transfer to *Glomus* by Almeida & Schenck) (OSC #38,846), x 150. **3.** Loose sporocarp of *Glomus intraradix* Schenck & Smith, (Morton #513), x 66. **4.** Germination of a *G. intraradix* spore (Morton #783), arrow points to germ tube, x 420. **5.** A spore resembling *G. tortuosum* Schenck & Smith (Olexia #156), with a sinuous outer hyphal mantle (hm) covering the laminated wall, x 140. **6.** Complex outer wall structure of *G. fragilistratum* Skou & Jakobsen (Skou #33), x 335. **7.** Spore of *G. mosseae* (Nicol. & Gerd.) Gerd. & Trappe (Morton #787) in Melzer's reagent, arrow points to curved septum in subtending hypha (sh), x 215. **8.** A spore resembling *G. claroideum* Schenck & Smith (Morton #785) in Melzer's reagent, x 242. **9.** A young spore of *G. intraradix* from a 6-week-old sudangrass pot culture (Morton #832), in Melzer's reagent, x 350. **10.** A mature spore of *G. intraradix* from the same culture after 4 months growth, in Melzer's reagent, x 300.

Cladogenesis of *Acaulospora* and *Entrophospora* from a common (hypothetical) ancestor (Morton, 1990a) and subsequent radiation into "sister groups" discloses "historical equivalence" (Wiley, 1980). Emergence of the sporiferous saccule (Figs. 11-12) pinpoints divergence of Acaulosporaceae from Glomaceae. The causal source of this evolutionary novelty is a matter of conjecture since the fossil record is unhelpful. Either some form of parasexual recombination led to the incorporation of new structural and regulatory genes or the sporiferous saccule emerged *de novo* from macromutations in a *Glomus* genotype. Other unique characters emerged (Table 1) during evolution of species initially constrained by this exclusive mode of spore development. Parallel sequences in spore ontogeny and organization are evident in *Acaulospora* and *Entrophospora*. It is so dramatic that species in both genera cannot be distinguished easily without knowledge of hyphal attachment(s). This is exemplified by *A. dilatata* Morton and *E. colombiana* Spain & Schenck (Figs. 14-15), which have indistinguishable spore wall structure (Fig. 29). The large number of character states common to both genera could be the result of common extrinsic selection pressures in ancestral species which led to similar epigenetic constraints in spore development (Morton, 1990b).

Parallelisms signify commonality in genetic background and kindred "evolutionary potentiality" (Cronquist, 1963). Parallelisms common to both Glomaceae and Acaulosporaceae corroborate their close phylogenetic affinities. These characters include: (i) an inner flexible wall which can range in appearance from membranous to semi-rigid, (ii) loose to compact aggregation of spores, (iii) vesicle development in mycorrhizal roots (Figs. 32-33), and (iv) mycorrhizae of some species which stain faintly or not at all in trypan blue (Morton, 1988).

Ontogenetic events in *Acaulospora* and *Entrophospora* appear to be similar at the light microscope level, although only two species of the former and one of the latter have been examined (Morton, unpubl.). Wall groupings originally proposed by Walker (1983) now appear to be highly significant in delineating developmental stages in spore maturation. They explicitly pinpoint temporal breaks in the synthesis of different wall types of the mature spore. In *A. spinosa*, the ornamented structural wall formed first (Fig. 16), a semi-rigid unit wall developed next (Fig. 17), and flexible inner walls formed last (Fig. 18). The synthesis of flexible walls of the inner wall group could not be separated temporally, although a change in Melzer's reaction of the innermost membranous wall from neutral to red-brown indicated that it was the last to mature (Fig. 18). This ontogenetic sequence sets Acaulosporaceae apart from other families in the Glomales.

Figs. 11-19. "Chlamydospores" of species in Acaulosporaceae, mounted in polyvinyl-lactic acid-glycerin (PVLG) and photographed using Nomarski interference optics. Wall numbers correspond to those on murographs depicted in Fig. 29. **11.** Young spore of *A. laevis* Gerd. & Trappe (Morton #579), s = spore, sp = sporiferous saccule, x 120. **12.** Mature spore of *E. colombiana* Spain & Schenck (INVAM #356), broken to show the inner flexible walls still intact as an "endospore", x 165. **13.** Spore of *A. appendicula* Spain, Sieverding & Schenck, (Morton #674) with subtending hypha (sh), x 125. **14.** Spore of *A. dilatata* Morton (Morton #469) in Melzer's reagent, x 250. **15.** Spore of *E. colombiana* (Morton #859) in Melzer's reagent, arrows point to hyphal attachment sites, x 350. **16-18.** Stages in ontogeny of *A. spinosa* Walker & Trappe spores (Morton #745) in Melzer's reagent. **16.** Young spore with only three walls present, x 250. **17.** More mature spore with four walls, x 280. **18.** Fully mature spore with 6 walls, the innermost wall staining red, arrow points to "collar" connecting spore to saccule neck, x 280. **19.** Germination compartments (large arrow) between the semi-rigid wall 3 and the beaded membranous wall 4 of *A. delicata* Walker, Pfeiffer & Bloss (Morton, #793), small arrow points to germ tube, x 330.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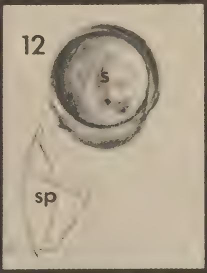
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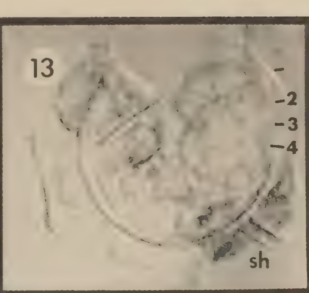
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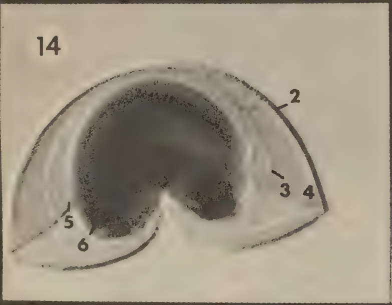
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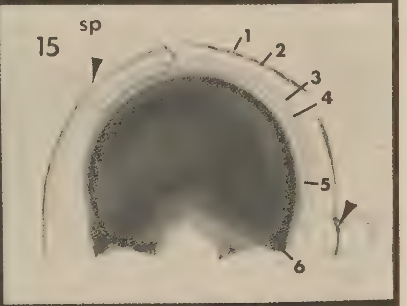
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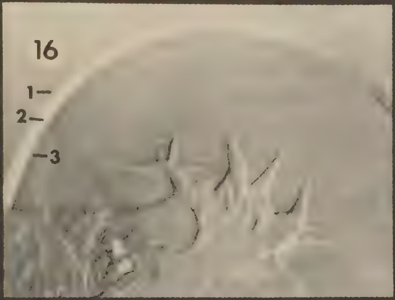
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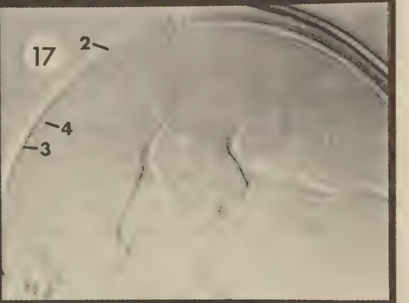
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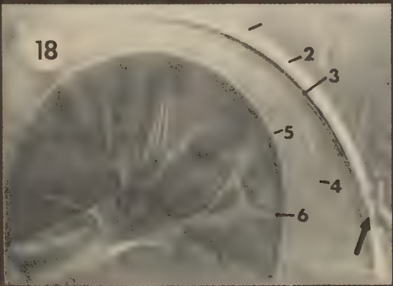
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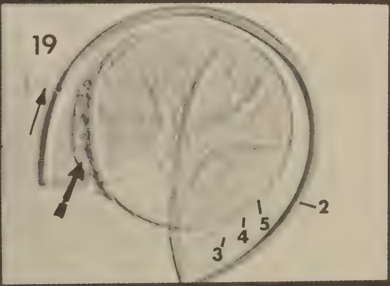
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Mosse (1970) accurately described the "germination compartments" formed in *A. laevis* Gerd. & Trappe, but the absence of observations at the light microscope level failed to expose the ephemeral nature of this structure. In separate observations of germinating spores of *A. laevis* (contributed by C. Gazey and L. Abbott) and *A. delicata* Walker, Pfeiffer & Bloss (from WVU pot cultures), germination compartments were detected between the semi-rigid unit wall and the beaded membranous wall (Fig. 19). These compartments retained structural integrity only when they remained firmly bounded by both walls. When these walls were fractured in crushed spores, the compartments became completely disrupted and were no longer recognizable. Even in intact spores, these compartments still cannot be seen except in transverse views. Thus, this pre-germination structure is morphologically distinct from that in *Scutellispora* spores (Walker and Sanders, 1986). We infer similar germination in *Entrophospora* species, although it has yet to be verified. Germination has not been described for the more primitive transitional species (e.g. *A. appendicula* and *E. infrequens* Ames & Schneider). Knowledge of these events will be important in further documenting relationships between Glomaceae and Acaulosporaceae.

In mycorrhizal roots, intraradical vesicles of both *Acaulospora* and *Entrophospora* are highly variable in shape (Figs. 32-33). They appear to be more more irregularly shaped than those in the Glomaceae, ranging from sausage-shaped (McGee, 1986) to highly lobed (Gerdemann and Trappe, 1974).

Gigasporineae Morton et Benny, **subord. nov.**

Solum arbuscules in mycorrhizarum radices efformatae. Azygosporae in in terra singulares productae; formatur in apice cellulae sporogenae. Cellulae auxiliares efformatae.

Only arbuscules formed in mycorrhizal roots (Figs. 34-35). "Azygospores" formed on the apex of a sporogenous cell. Auxiliary cells formed.

The Gigasporaceae are not vesicular-arbuscular mycorrhizal (or VAM) fungi. They do not form intraradical vesicles in mycorrhizal roots. There is no evidence that auxiliary cells (Fig. 35) are a substitute for the vesicles found in mycorrhizae of Glomaceae and Acaulosporaceae (Figs. 30-33). These extraradical structures are more reminiscent of relict reproductive spores. They do not germinate readily, they show no evidence of being capable of initiating mycorrhizal infection, and morphological complexity of the cell wall is being reversed from highly ornamented cells in *Gigaspora* to smooth in some species of *Scutellispora*. Their persistence in extant taxa may be due to the stabilizing effects of the symbiosis. Strong directional selection pressures against synthesis of auxiliary cell would not develop as long as fitness was not reduced substantially.

Taxa in Gigasporineae have few spore or mycorrhizal characters homologous with those in other families, except for intraradical arbuscular development (Morton, 1990a). The "azygospores" are so distinct developmentally that relatedness to other arbuscular or non-arbuscular zygomycetous fungi is difficult to establish. Structures such as the sporogenous cell and the ever-present hyphal peg branching from this cell (Figs. 11-16) are features suggestive of a development unique from that of sporangia or azygospores in other zygomyceteous fungi. Tommerup (1988) reports separate "azygospores" during zygosporogenesis in *Gigaspora decipiens* Hall & Abbott, but their true identity remains equivocal in the absence of complete descriptions. Walker (1987) suggests that resting spores may be unispored sporangia, a conclusion based on continuity between the outermost unit spore wall and the wall of the sporogenous cell (Gibson et al., 1987). Much more needs to be done examining nuclear condition and hormonal interactions to pin down spore properties.

The absence of a fossil record for Gigasporineae is unfortunate, because the origin of this suborder cannot be resolved cladistically (Morton, 1990a). Evidence of a putative sexual stage in *Gigaspora* (Tommerup, 1988) as well as substantive morphological divergence from a presumed glomuslike ancestor (Morton, 1990a) suggests an independent origin, possibly later in plant evolution.

Rapid morphological divergence of a primitive *Gigaspora* from a glomuslike ancestor cannot be ruled out. But why are there no intermediate species between Glomaceae and Gigasporaceae like those found in the Acaulosporaceae? Assessment of the extent of molecular relatedness relative to morphological divergence (Bruns et al., 1989) in arbuscular families will help to resolve this question. Aldwell et al. (1985) found greater immunological relatedness between hyphal antigens of Acaulosporaceae and Gigasporaceae than those from Glomaceae. These results support the common ancestor hypothesis, but morphological evidence provides strong evidence that the antigens indicated convergence.

Gigasporaceae Morton et Benny, **fam. nov.**

Azygosporae in terra singulares productae, plerumque magnae, globosae vel subglobosae, formantur in apice cellulae sporogenae, cum hypha angusta ad sporam extensa. Azygosporae minimis parietibus duobus; paries externus tenuis; paries interiore lamellatus. Tubuli germinativi parietem prope basim azygosporae directe penetrantes vel ex germinationis clipeo producti. Cellulae auxiliares prietibus tenuis plerumque in terra a hyphis circinatis in greges confertae; superficies spinosa ad laevis. Endomycorrhizae arbusculis in radicibus efferentes.

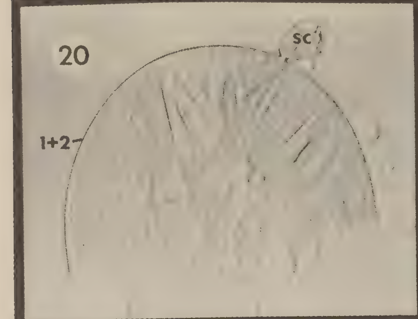
"Azygospores" generally large, globose to subglobose, borne singly in soil on a sporogenous cell with a lateral peg often protruding toward the spore. Azygospores with a minimum of two walls; a thin outer unit wall enclosing a structural laminated wall. Germ tubes produced directly through the wall or from a germination shield. Thin-walled auxiliary cells produced usually in clusters on coiled hyphae in soil; surface ranging from echinulate to smooth. Mycorrhizae forming arbuscules in roots.

Spores generally large, globose to subglobose, borne singly in soil on a sporogenous cell with a lateral peg often protruding toward the spore. Sporangia-like spores with a minimum of two walls: a thin outer unit wall enclosing a structural laminated wall. Germ tubes produced directly through the wall or from a germination shield. Thin-walled auxiliary cells produced usually in clusters on coiled hyphae in soil; surface ranging from echinulate to smooth. Mycorrhizae forming arbuscules in roots.

Type genus: *Gigaspora*, Gerd. & Trappe, 1974 (*Mycologia Mem.* **5**: 25).

Other taxon: *Scutellispora* Walker & Sanders, 1986 (*Mycotaxon* **27**: 179).

Members of *Gigaspora* have no uniquely derived characters (autapomorphies) that distinguish them from species in *Scutellispora* (Morton, 1990a). This pattern in character distribution indicates that the former genus is ancestral to the latter. Ontogeny of spores in *Scutellispora* also corroborates *Gigaspora* as a primitive ancestor [see Nelson (1978) for discussion of Haeckel's biogenetic law of ontogeny recapitulating phylogeny]. Young spores of *Scutellispora* (Fig. 22) are identical in wall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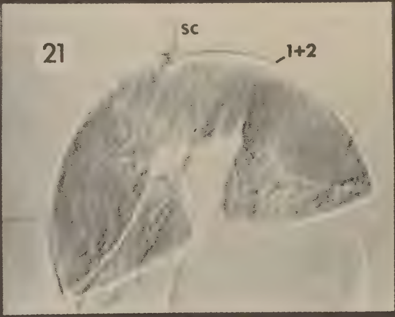
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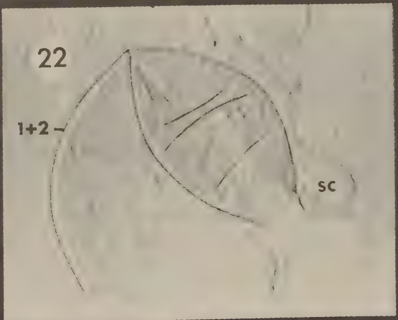
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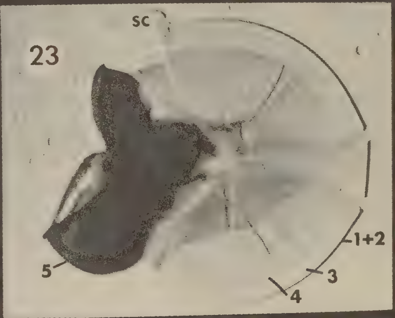
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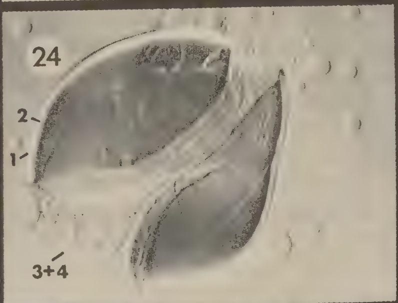
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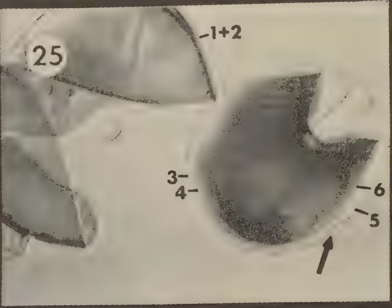
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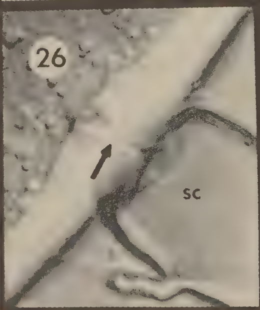
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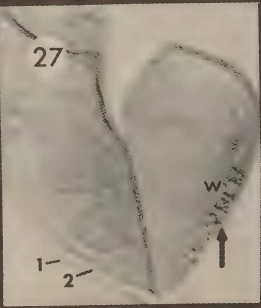
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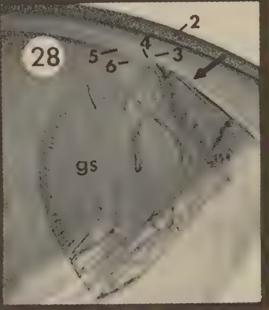
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structure to those of *Gigaspora* young or old (Figs. 20-21). The two outer (structural) walls of *Scutellispora* spores are temporally uncoupled from development of the inner flexible walls (Figs. 22-23).

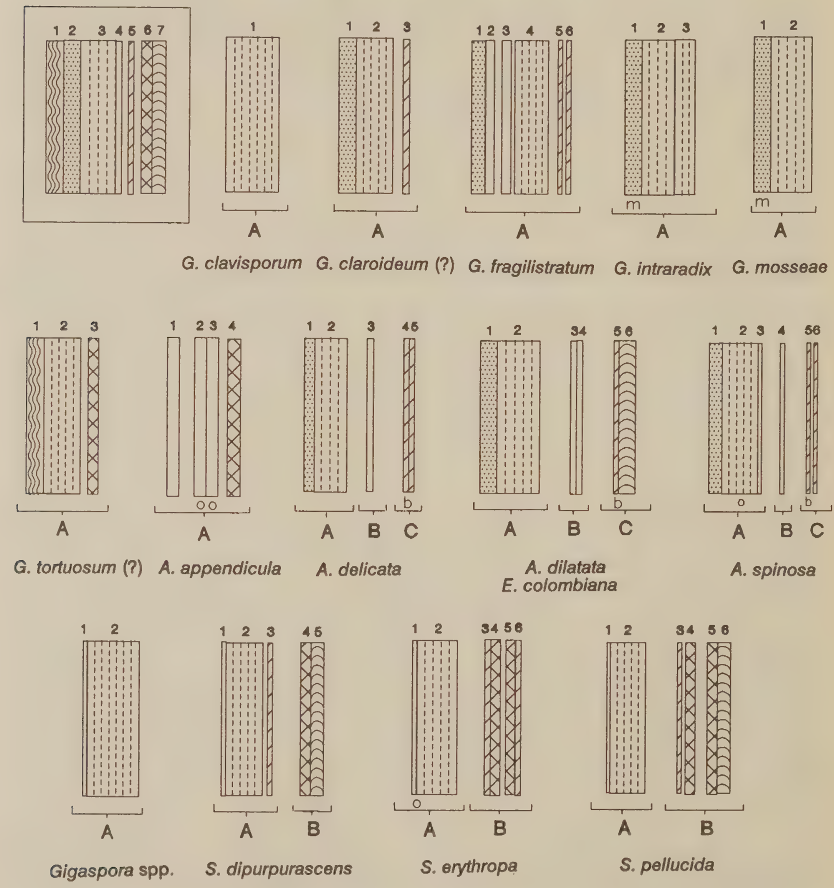
Maintaining *Gigaspora* and *Scutellispora* as separate genera is misleading for biologists who interpret classification as a direct representation of cladogenesis (Eldredge and Cracraft, 1980). For example, *Acaulospora* and *Entrophospora* are sister groups in the Acaulosporaceae and hence they have approximate equivalence historically. *Gigaspora* is clearly ancestral to *Scutellispora*, and both genera technically should be grouped together (similar to the glomuslike and sessile spore forms of *Acaulospora*). Otherwise, it is interpreted cladistically as a paraphyletic group (Donoghue and Cantino, 1988). We have chosen to sustain this imperfect phenetic separation of *Gigaspora* and *Scutellispora* for the time being until transitional stages between the germinal wall (in *Gigaspora*) and the germination shield (in *Scutellispora*) are more thoroughly investigated. As it stands, origin of *Scutellispora* is marked by major evolutionary advances in organization or "grade" (Mayr, 1963) of spore phenotypes. Virtually all morphological divergence in Gigasporaceae is manifested in *Scutellispora*, where a number of unique morphological characters evolved (Table 1). The sexual stage found only in *Gi. decipiens* could have provided the genetic diversity to ameliorate origin and adaptive radiation (and speciation) in *Scutellispora* from a *Gigaspora* ancestor persisting to the present day. Certainly, evolutionary novelties arose and spread from rather than within *Gigaspora*. The development of an inner flexible wall complex in *Scutellispora* may have had considerable adaptive significance at the time of speciation by providing an additional barrier (as an endospore) against parasitism or some other disruptive extrinsic biotic or abiotic factors. The development of at least one flexible inner wall is directly correlated with origin of the germination shield (Walker and Sanders, 1986). The emergence of additional inner walls, so that the germination shield is positioned between them (Figs. 25, 28), may have had additional adaptive value.

Interspecific morphological divergence in *Gigaspora* is nominal, being limited to quantitative and qualitative characters of questionable heritability (phenotypically too variable). The number of species is low and the distinctions between them are highly equivocal (Morton, 1988). We predict that many species will be combined, so that their number will decrease with time rather than increase. Some continuous characters (e.g. spore size, color, wall thickness, etc.) now used to delimit species may eventually have evolutionary significance [and hence taxonomic value--see Morton (1990b)] once discriminant analyses (Sneath and Sokal, 1973) are applied to sorting

---

Figs. 20-28. "Azygospores" of species in Gigasporaceae, mounted in polyvinyl-lactic acid-glycerin (PVLG) and photographed using Nomarski interference optics. Wall numbers correspond to those on murographs depicted in Fig. 29. **20.** Immature spore of *Gigaspora margarita* Becker & Hall (Morton #836), sc = sporogenous cell, x 176. **21.** Mature spore of *Gi. margarita* from same culture, x 115. **22.** Immature spore of *S. dipurpurascens* Morton & Koske (Morton #666) in Melzer's reagent, x 100. **23.** Mature spore of *S. dipurpurascens* in Melzer's reagent (Morton #666) x 140. **24.** Immature spore of *S. pellucida* (Nicol. & Schenck) Walker & Sanders (Morton #611) in Melzer's reagent, only four walls present; x 140. **25.** Mature spore of *S. pellucida* in Melzer's reagent, all 6 walls present, arrow pointing to germination shield between walls 4 and 5; (Morton #611) x 120. **26.** Spore of *Gi. gigantea* (Nicol. & Gerd.) Gerd. & Trappe (Morton #550), showing membranous septum (arrow) partitioning spore contents from cytoplasm of the sporogenous cell (sc); x 736. **27.** Germinating spore of *Gi. decipiens* Hall & Abbott (Morton #890), arrow points to the germ tube surrounded by warts of the germinal wall, x 200. **28.** Spore of *S. dipapillosa* (Walker and Koske) Walker & Sanders (Morton #602) in Melzer's reagent, arrow points to the hole left by the germ tube that grew from the germination shield (gs); x 250.

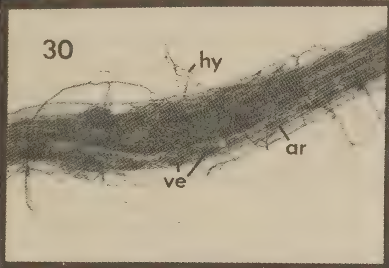
Fig. 29. Murographs of spore wall structure of species photographed in Figs. 2-28. Walls are numbered consecutively from outer to inner surface of spore. Each wall group is bracketed in parentheses with consecutive capital letters from outer to inner surface of spore. "o" = ornamented, "b" = beaded, "m" = mucilagenous. Numbers above fill patterns in upper left corner bounded box correspond to the following wall types: 1 = peridium (mantle), 2 = evanescent, 3 = laminated, 4 = unit, 5 = membranous, 6 = coriaceous, 7 = amorphous.

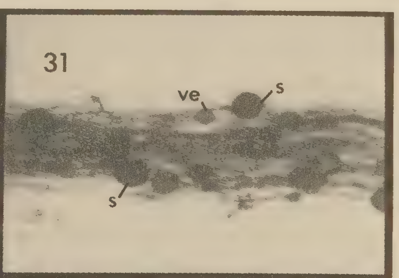

1 2 3 4 5 6 7
1
A
G. clavisporum
1 2 3
A
G. claroideum (?)
1 2 3 4 5 6
A
G. fragilistratum
1 2 3
m
A
G. intraradix
1 2
m
A
G. mosseae
1 2 3
A
G. tortuosum (?)
1 2 3 4
o o
A
A. appendicula
1 2 3 4 5
b
A B C
A. delicata
1 2 3 4 5 6
b
A B C
A. dilatata
E. colombiana
1 2 3 4 5 6
o
b
A B C
A. spinosa
1 2
A
Gigaspora spp.
1 2 3 4 5
A B
S. dipurpurascens
1 2 3 4 5 6
o
A B
S. erythropa
1 2 3 4 5 6
A B
S. pellucida

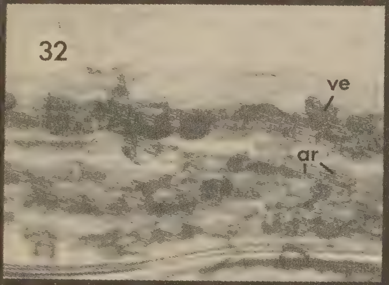
Figs. 30-35. Endomycorrhizal roots of red clover (*Trifolium pratense* L.) grown in greenhouse pot cultures; mounted in polyvinyl-lactic acid-glycerin (PVLG). **30.** Vesicular (ve) and arbuscular (ar) colonization by *G. etunicatum* Becker & Gerd. (Morton #579), with extraradical hyphae (hy) growing along outside of root, x 130. **31.** Vesicle (ve) and intraradical sporulation (sp) by *Glomus intraradix* Schenck & Smith (Morton #832), x 195. **32.** Vesicular-arbuscular colonization by *A. spinosa* Walker and Trappe (Morton #745), x 250. **33.** Lobed vesicles (ve) produced by *E. colombiana* Spain & Schenck (INVAM #356), x 325. **34.** Arbuscular colonization (ar) by *Gi. margarita* Becker & Hall (Morton #836), x 300. **35.** Auxiliary cells (au) produced by *S. dipurpurascens* Morton & Koske (Morton #666), x 60. →

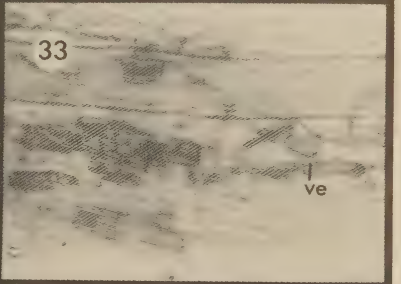
phenetic discontinuities. By most measurable parameters, *Gigaspora* appears to be composed of species which, *historically*, were precariously adapted to the environment in which they originated and that emergence of *Scutellispora* was a natural consequence. The fact that *Gigaspora* is not extinct is indicative of evolutionary stasis and persistence not paralleled in too many other groups of living organisms (Morton, 1990b).

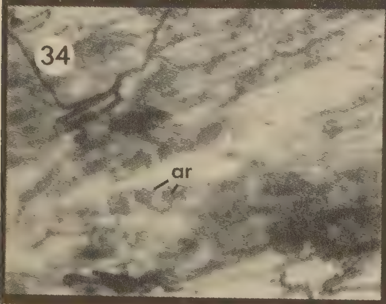
Ontogeny has been followed in spores of several *Scutellispora* species, with *S. pellucida* serving as the representative species in this paper. In young spores, the outer unit and second laminated walls appear to be synthesized almost simultaneously. Spores resemble those seen in Figs. 20 and 22. A dextrinoid reaction in the laminated wall (Fig. 25) sometimes occurs even before the inner flexible wall group forms. This indicates that the temporal gap between structural wall development and flexible wall development is protracted relative to that *within* each group. The inner flexible walls

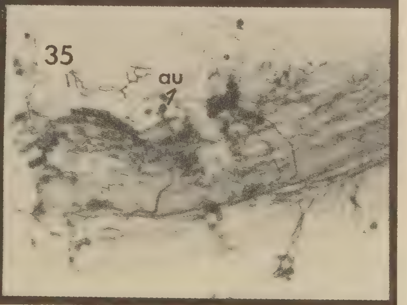












form sequentially from outer to innermost wall, but a temporal break can be detected between flexible walls formed "above" (membranous + coriaceous) (Fig. 24) and "below" (coriaceous + amorphous) the germination shield (Fig. 25). All inner walls appear membranous initially, after which they take on the appearance of mature wall types. The germination shield never is synthesized before all spore walls are fully mature (based on dark red-purple reaction of the innermost amorphous wall in Melzer's reagent) (Fig. 25).

Temporal discontinuities in spore wall development are grossly correlated with number of wall groups. The exception are those species with a germination shield *between* flexible walls, because walls on each side of the germination shield develop discretely. They still appear as one wall group (or "endospore") because of their elasticity [see Fig. 11 in Morton (1988)].

KEY TO TAXA IN GLOMALES

A. Only arbuscules formed in mycorrhizal roots; "Azygospores" produced on the apex of a sporogenous cell of a fertile hypha; auxiliary cells formed . GIGASPORINEAE

With a single family .... Gigasporaceae (B)

- B. Germ tubes produced directly through spore wall; inner flexible wall group absent; auxiliary cells finely papillate or echinulate .... *Gigaspora*
- BB. Germ tubes from germination shield; inner flexible wall group always present; auxiliary cells knobby, broadly papillate, or smooth .... *Scutellispora*

AA. Arbuscules and vesicles formed in mycorrhizal roots. "Chlamydospores" produced terminally or laterally on or within fertile hyphae; auxiliary cells not produced .... GLOMINEAE (C)

- C. "Chlamydospores" formed apically from fertile hyphae .... Glomaceae (D)
  - D. Fruiting body of a sporocarp composed of spores will lateral walls adherent to one another; connecting hyphae embedded in a central hyphal plexus; chlamydospores in a single layer except at the base; base composed of sterile hyphae .... *Sclerocystis*
  - DD. Fruiting structure a sporocarp not formed as in "D" above; spores also produced singly or in loose to tight aggregates in soil, less commonly in roots .... *Glomus*
- CC. "Chlamydospores" formed from or within the "neck" of a sporiferous saccule .... Acaulosporaceae (E)
  - E. Spores arise laterally from the neck of a sporiferous saccule .... *Acaulospora*
  - EE. Spores formed in the neck of the sporiferous saccule .... *Entrophospora*

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SPECIES AND CLONES OF ARBUSCULAR MYCORRHIZAL FUNGI (GLOMALES, ZYGOMYCETES): THEIR ROLE IN MACRO- AND MICROEVOLUTIONARY PROCESSES

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ABSTRACT

Species of arbuscular mycorrhizal fungi (Glomales, Zygomycetes) are discrete entities recognized by distribution of phenetically well-defined characters and related by common descent. A model of macroevolution is proposed in which (i) mutualism arose between an asexually-reproducing terrestrial plant and zygomycete fungus, (ii) speciation of arbuscular fungi occurred while mutualism evolved and spread among radiating plant lineages, (iii) species persisted from time of origin to present day relatively unchanged in spore phenotypes and with zero rate extinction, and (iv) evolutionary changes in the fungi following speciation involved modification of mycorrhizal phenotypes to maximize co-adaptation of clones and host species. Species are considered historical entities, with clonal populations as the fundamental units of contemporary evolutionary change. Experimental results can be extrapolated to the level of species or supraspecific taxa only with an adequate sampling of dissimilar clonal populations.

Key Words: Endogonaceae, Endogonales, vesicular-arbuscular mycorrhizae, phenetics, cladistics, phylogeny

INTRODUCTION

Arbuscular mycorrhizal fungi are an important group of soil-borne microorganisms that contribute substantially to the establishment, productivity, and longevity of natural or man-made ecosystems (Harley and Smith, 1983). These fungi form obligate mutualistic associations in roots of most terrestrial plant families (Trappe, 1987). Their role in natural and man-made ecosystems still is poorly understood, in part because systematics has not provided the theoretical base for relating fungal diversity/similarity to the range of biological interactions that exists in nature.

To date, classification and identification have been based on a typological perspective (Gerdemann and Trappe, 1974; Morton, 1988). While research has been carried out at a rapid rate [see books edited by Harley and Smith (1983), Powell and Bagyaraj (1984) and Safir (1987)], the science of systematics has not kept pace. No rigorous attempts were made to answer important basic questions such as: What is a species? What kinds and amount of variability exist within and between species? What physical and biological forces contribute to origin, maintenance and extinction of species? Is a species the appropriate level within the geneological hierarchy to examine the multitude of interactions between fungal symbionts, hosts, and physical environments? The answer to these questions require some understanding of evolutionary relationships because they provide "the largest number of useful biological generalizations and hypotheses" (Bock, 1977).

Evolutionary theory, as applied to mutualistic arbuscular fungi, has not included a systematic component. Law (1985) and Law and Lewis (1983) addressed evolution of mutualistic symbioses, but with a focus on emergence and adaptive value of sexual and asexual reproductive systems. Macroevolutionary hypotheses have been proposed (Malloch et al., 1980; Malloch, 1987; Pirozynski, 1981; Pirozynski and Dalpé, 1989; Pirozynski and Malloch, 1975), but without explicit recognition of basic evolutionary units or the relationships between them.

A burgeoning number of new species descriptions in recent years established a reasonable data base of organismal diversity to assess stability and distribution of characters (Morton, 1988; 1989) and the extent to which these characters established a pattern of evolutionary change among known taxa (Morton, 1990). These data, along with ontogenetic evidence, was used to revise classification of arbuscular fungi so that it reflected more natural groupings (Morton and Benny, 1990). The next logical step was to study evolutionary processes from an analysis of these geneological patterns. In this paper, both paleontological and neontological data are used to formulate a species concept and assess genetic change within (microevolution) and among (macroevolution) those species. Spelling of scientific names of arbuscular fungi in this paper are according to recommendations of Almeida (1989).

A SPECIES CONCEPT

No species definition can achieve complete operational and theoretical utility in describing the full range of biological phenomena (Hull, 1970). At the least, a working species concept provides a conceptual framework to guide decision-making efforts of researchers. It must take into account historical events (development of geneological patterns), an unambiguous measure of character variability, and most of all, unique aspects of the organism's life history that affect genetic change.

Life history.--Arbuscular fungi have a bimodal pattern of differentiation. The vegetative phase consists of intra- and extraradical coenocytic hyphae and dichotomously-branched intraradical arbuscules in plant roots. Together, these organs are important in the acquisition of carbon and nutrients for vegetative growth (Bowen, 1987; Harley and Smith, 1983). Vesicles in roots generally appear to serve mostly as storage organs (Bonfante-Faseolo, 1984) rather than as infective propagules, although the latter has been reported by Biermann and Linderman (1983). The fungus depends totally on the plant host during this phase of its life cycle, but the specialized obligate biotrophy is offset by an almost unrestricted host range. For example, at least 30% of known species have been propagated successfully just on *Sorghum sudanense* (Piper) Staph. (Morton, unpubl.) and *Paspalum notatum* Flügge (Schenck and Pérez, pers. commun.) in greenhouse pot cultures. Reproductive structures are asexual spores (putative chlamydospores or azygospores) produced within or outside of host roots. The spores are phenotypically diverse propagules which have several discrete functions: (i) dissemination of clonal individuals beyond the range of extraradical hyphae and (ii) short-term survival of the clone in plant-deficient environments or in soils too harsh for spore germination and host colonization (Daniels Hetrick, 1984). Spores are autonomous entities once they mature and become physiologically isolated from the vegetative thallus. Although somatic and reproductive phases of the mycorrhizal fungus are interdependent in maximizing fitness and survival of the fungus, each has marked physiological independence. Spore phenotypes serve as primary criteria for measuring species differences because morphological divergence is much greater than that observed in mycorrhizal phenotypes.

Biological species concept.--Biological species consist of interbreeding populations with a common gene pool (Cronquist, 1988; Mayr, 1963; Simpson, 1961). Speciation is recognized when reproductive discontinuities disrupt gene flow in a population enough so that it becomes genetically isolated, regardless of the amount of morphological change. This concept has broad applicability to animals with somatic and reproductive organs integral to the body of the whole organism. However, it begins to break down with plants and fungi, where reproductive structures are more loosely linked to vegetative parts (Cronquist, 1988).

Arbuscular species cannot be considered biological species because most appear to be obligately asexual. One species (*Gigaspora decipiens* Hall & Abbott) may have some capability for sexual reproduction (Tommerup, 1988), but documentation is sparse and needs further amplification. In this discussion, populations of arbuscular fungi are considered to be reproductively isolated. Morphologically identical clones constitute subparts of a species.

Parasexual (nonmeiotic) recombination is a potential source of significant genic interchange between clones. However, hyphal anastamosis appears to be infrequent between spores of disjunct clonal populations of the same arbuscular species and virtually nil between those of different species (Tommerup, 1988). This evidence suggests that parasexual activity is not great enough to contribute significantly to speciation events.

Ecological species concept.--Van Valen (1976) proposed an "ecological species" to include the criterion of "adaptive zone" occupation as well as that of reproductive isolation. This definition applies to those asexual organisms which occupy species-specific habitats. However, arbuscular species cannot be correlated with particular host-soil environments (Bloss and Walker, 1987; Gerdemann and Trappe, 1974; Koske, 1987). Instead, an "ecological *order* concept" applies to arbuscular taxa because they all occupy a similar "adaptive zone" or "collective niche" (Simpson, 1961) in the roots of plant hosts. All species in Glomales (Morton and Benny, 1990): (i) are obligately biotrophic (Lewis, 1973), (ii) acquire carbon and interface with host plants via intraradical arbuscules (Bowen, 1987; Harley and Smith, 1983), and (iii) experience considerable ecological amplitude by virtue of a broad host range (Mosse et al., 1981).

Phenetic species concept.--Claims have been made that classification of arbuscular fungi has been phenetic (Walker, 1987). This is true only to the extent that relationships among obvious and invariant morphological characters have been given taxonomic priority in defining species and supraspecific taxa. Variability in continuous qualitative (e.g. spore color, shape) or quantitative (e.g. spore size, wall thickness, hyphal width) characters never have been evaluated rigorously in empirical studies.

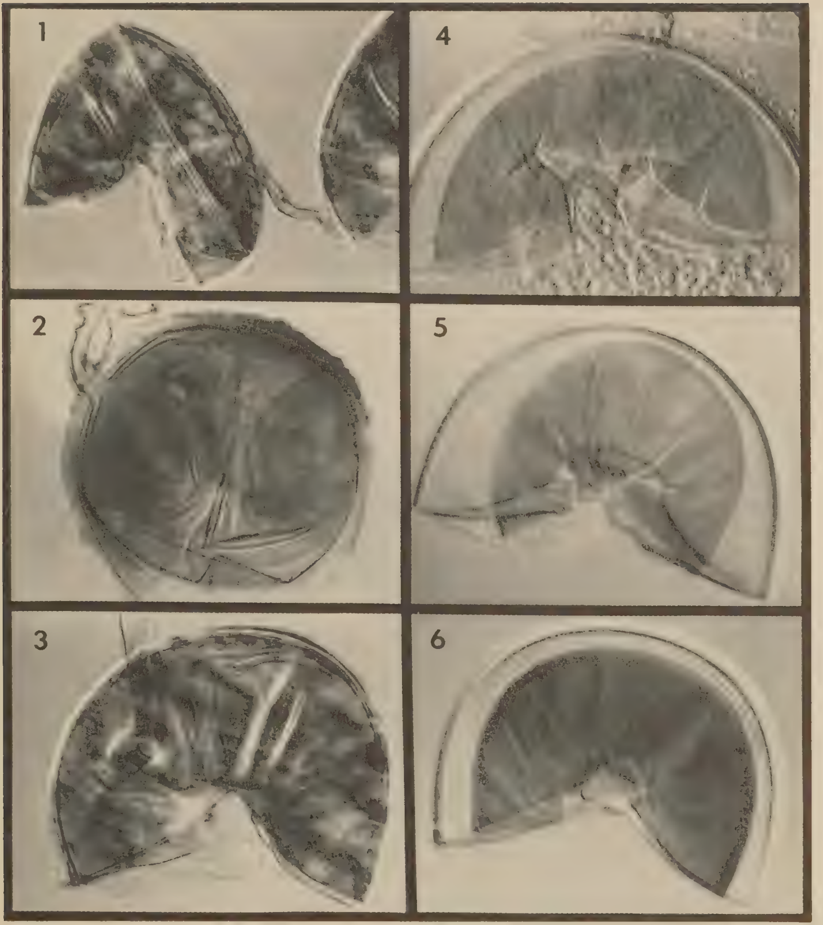
Phenetic species are grouped hierarchially by indices of *overall* similarity in characters. The most frequently used methods are hierarchial cluster analysis, calculation of similarity indices, and discriminant analysis (Duncan and Baum, 1981; Sneath and Sokal, 1973). These methods also are helpful in estimating intra- and interspecific character variability. From these data, *a posteriori* decisions can be made regarding consistency of characters (and hence their taxonomic weight). The main weakness of the phenetic species is that it excludes any consideration of evolutionary history and this can lead to artificial classifications (Mayr, 1965). In the Glomales, for example, correlations among *all* characters would show greater affinities between Acaulosporaceae and Gigasporaceae than with Glomaceae. Relatedness among these families are reversed using evolutionary criteria (Morton and Benny, 1990).

Evolutionary species concept.--Wiley (1978) interpreted an evolutionary species as "a single lineage of ancestor-descendant populations of organisms which maintains its identity from other such lineages and which has its own evolutionary tendencies and historic fate". Cladistic methods are used to devise cladograms that assess patterns of morphological divergence (Hennig, 1965). When measures of anagenetic change (patristic distance) complement branching patterns, phylogenetic trees can be constructed (Stuessy, 1987). Characters are weighted *a priori* (or iteratively) according to their ability to resolve linear and branching patterns of evolutionary change among species (Eldredge and Cracraft, 1980). Fortunately, enough characters *currently perceived* as being invariant were available among arbuscular species to interpret congruent patterns of descent with modification, despite clonal reproduction (Morton, 1990). The main weakness of cladistic and evolutionary methods is that they often rely on restricted character sets. Many characters were not considered in cladistic analysis of arbuscular taxa because phenotypic variability was not defined well enough to define evolutionary significance. Their taxonomic value ultimately will depend on more thorough phenetic analyses.

Of all the species concepts discussed above (biological, ecological, phenetic, evolutionary), only the phenetic and evolutionary concepts together embrace the unique biological properties of arbuscular fungi. The key element of an arbuscular species definition concerns defining *those characters which recognize biologically significant speciation events*. These events must involve morphological change in populations already reproductively isolated (as clones). Invariant characters are highly significant because they are expressed regardless of environmental influence. The challenge remaining is to sort out continuous characters and determine which have greater inter- than intra-specific variability (Morton, 1988). More characters, along with ontogenetic, biochemical, and molecular data, will help to clarify this picture.

Both phenetic and evolutionary species concepts recognize species as cohesive entities. Species integrity clearly is maintained in spore phenotypes of: (i) distant geographic clonal populations (Figs. 1-6), (ii) clones subjected to short-term host-soil selection pressures in greenhouse experiments (Morton, 1985) and (iii) clonal populations subcultured repeatedly in pots for up to nine years (Morton, unpubl.). Striking similarities also exist between fossilized and extant arbuscular species, suggesting morphological stability over a period of 400 million years (Pirozynski and Dalpé, 1989; Stubblefield and Taylor, 1988). Independent criteria also indicate species cohesiveness in the absence of interbreeding. Monoclonal antibodies produced against one clonal population of *Glomus occultum* Walker react only with other clones of the same species, regardless of their geographical origin (Wright et al., 1987). Similarly, isozyme banding patterns show greater intra-specific than inter-specific similarity (Hepper et al. 1988).

Species of many groups of organisms have been viewed as "individuals" or spatiotemporally discrete entities (Ghiselin, 1974). Arbuscular species have a discrete origin, but they are not spatially restricted by particular niches (or host-soil environments). At the same time, mycorrhizal hyphae are totipotent and, by virtue of an indeterminant growth habit, they can persistently colonize any available plant roots. Thus, species resemble "classes" that are separated by "timeless" spore phenotypic characters. It is clones (or subparts) of a species which truly represent "individuals". Each clonal population may have one or more distinct genotypes (expressed in the mycorrhizal phenotype) of discrete origin. Being localized geographically, each clone is potentially subject to extinction.



Figs. 1-6. 1-3. Clonal isolates of *Glomus intraradix* Schenck & Smith propagated on sudangrass in pot culture, mounted in polyvinyl alcohol-lactic acid (PVLG) and Melzer's reagent (1:1 v/v), and photographed using Nomarski Interference optics. **1.** Isolate from INVAM (#208), x 285. **2.** Isolate from O. Nopamornbodi, Thailand, x 310. **3.** Isolate from R. Koske, Hawaii (Morton #692), x 250. **4-6.** Clonal isolates of *Acaulospora spinosa* Walker & Trappe mounted and photographed similarly. **4.** Type specimen (OSC #40,080), x 375. **5.** Isolate from M. Gavito Pardo, Tlaxcala, Mexico, x 340. **6.** Isolate from West Virginia (Morton #745), x 275.

MACROEVOLUTION

Macroevolution involves study of patterns of diversity within supraspecific taxa. Macroevolutionary trends do not lend themselves to empirical analysis because they are historical rather than contemporary (Eldredge, 1989). Many view that genetic change and selection occurring within species (see "Microevolution") can be extrapolated to supraspecific taxa over geological time (Eldredge and Cracraft, 1980; Mayr, 1963; Simpson, 1961). With development of the theory of punctuated equilibrium (Gould and Eldredge, 1977) to explain gaps in the fossil record, macroevolution became uncoupled conceptually and methodologically from those of microevolution (Gould and Eldredge, 1977; Eldredge and Cracraft, 1980; Stanley, 1975). Evidence for and against each theory has come from paleontological (Gould and Eldredge, 1977), population (Charlesworth et al, 1982), and philosophical (Ghiselin, 1974) analyses. Most of the biological systems scrutinized and compared, however, were of organisms having highly integrated somatic and reproductive functions (e.g. animals). These theories, as with the species concept elaborated above, are relevant only within the context of the unique biological properties of arbuscular fungi and of the mycorrhizal symbiosis.

Analysis of macroevolution of arbuscular fungi is complicated by several factors. First, evolution in terrestrial plants cannot be separated decisively from that of the fungal symbionts (Pirozynski, 1981). Second, mycorrhiza phenotypes emerged from long term interactions between host and fungal genotypes that were *both* influenced by the external environment in different phases of their life cycles. Third, intrinsic and extrinsic forces differentially affected the rate and extent of morphological change in mycorrhizal versus spore phenotypes, so that speciation events are delimited mostly by the latter.

Definitive evidence of origin and adaptive radiation of arbuscular species requires a relatively complete fossil record. Unfortunately, described fossils resembling contemporary analogues in the Glomales comprise less than 1% of the known morphological diversity, and they fail completely to represent two of the three major families (Morton and Benny, 1990). The only sound alternative is to reconstruct a phylogeny from character distributions among extant taxa. The phylogenetic tree hypothesized by Morton (1990) provided the following theoretical infrastructure necessary for macroevolutionary analysis: (i) monophyletic groups were descended from a common ancestor, (ii) character changes specified explicit ancestor-descendant relationships, and (iii) patterns of diversity could be related to biogeographical distribution of species and supraspecific taxa (Eldredge and Cracraft, 1980).

A model of evolution in the Glomales is proposed which addresses questions of origin, speciation, phenotypic divergence among lineages, and differential increase in the number of species in supraspecific taxa:

1. The progenitor of the Glomales was an asexual saprobic zygomycete fungus.
2. The most ancient terrestrial plants became established on land either independent of a fungal symbiosis or with an association that was neutral or weakly mutualistic.

3. The symbiosis arose from contact between host and fungus that was not maladaptive to either. Clonal reproduction in *both* partners insured faithful replication and fixation of favorable gene combinations. Evolution of mutualism was gradual rather than saltational.
4. New fungal species arose during co-evolution of the mutualistic symbiosis. Speciation stopped or it was greatly diminished after the fungus became obligately biotrophic and most plant lineages possessed genes ameliorating compatible interactions.
5. Descendant arbuscular species originated from one or more clones of the ancestral species in response to adaptations favoring fecundity, survival, and localized dissemination. Thus, the geographic distribution of the new species might not correlate with that of the ancestral species.
6. Species have persisted from about the Cretaceous to modern times relatively unchanged *in those spore phenotypes which delimit a species*. Trends in morphological change emerged from patterns of speciation rather than from differential extinction.
7. Clonal populations of species are the fundamental units of contemporary evolutionary processes. Genetic change in clonal genotypes are directed by selection pressures optimizing fitness of both partners, and this is expressed in mycorrhizal phenotypes.

The following arguments are presented to support the proposed model. This model is a hypothesis based on a small amount of data, in part because so little emphasis has been placed on the biology of the organisms in the mycorrhizal association. It is designed to serve as a rudimentary base for formulating new hypotheses about the biology and ecology of arbuscular fungi.

Point 1.--The fossil record pinpoints the Devonian period as first appearance of glomuslike "chlamydospores" in rhizomes of lycopsid and rhyniophyte plants (Pirozynski and Malloch, 1975). True origin of the symbiosis remains unknown, however, because the ancestor is not recognizable. Molecular analyses of primitive zygomycetous fungi eventually may provide some clues of close genetic ties with a modern fungus.

Pirozynski and Malloch (1975) and Pirozynski (1981) contend that the mycorrhizal association arose from an early saltational events that led to a partnership between an oomycete fungus and an algal progenitor of plants. However, the Glomales are not of oomycetous origin (Malloch, 1987). Arbuscular species have chitin in their cell walls (Weijman and Meuzelaar, 1979) and at least one species in the Gigasporaceae forms putative zygospores (Tommerup, 1988). Multiperforate septa also show a link between Glomales, Mucorales, and Endogonales (Gibson et al., 1986). These characters firmly place members of Glomales in the Zygomycetes. Similarities in lipid profiles with protistan fungi (Jabaji-Hare, 1988) are convergent characters (Morton, 1990) rather than indicators of phylogenetic relationships (Pirozynski and Dalpé, 1989).

Sexuality may have been present in the progenitor, but it is unlikely. That critical combination of host and fungus genes which provided some measure of initial compatability could have been lost or diluted in progeny if either or both partners were sexual (see "Point 3"). Genetic recombination would have been detrimental or even lethal to establishment and maintenance of these compatible gene combinations (Law, 1985; Law and Lewis, 1983).

Arguments that the fungal progenitor might have been saprobic rather than pathogenic (Heath, 1987; Malloch, 1987) are convincing and plausible. Since the ancestral form cannot be identified, however, no independent criteria are available to make a more informed decision among competing hypotheses.

Point 2.--Establishment of an obligate association between a progenitor (Oomycete) fungus was essential to a hypothesis that emergence of plants into a terrestrial habitat *required* an obligate mutualistic association and that this association was necessary for subsequent adaptive radiation in plant groups (Pirozynski and Malloch, 1975; Pirozynski, 1981). Reinterpretation of the ancestor as a zygomycete fungus places origin of the symbiosis at a later time than when fungi and plants were mainly aquatic. Plants probably did not become completely dependent on a mutualistic symbiosis from the moment they became land-based for several reasons: (i) beneficial effects of the association in expanding the absorptive zone of rhizomes would have slowed rather than increased selection pressure to differentiate new root architectures and vascularization and (ii) one of the evolutionary innovations of the Devonian (e.g. seed development) (Tiffney and Niklas, 1985) would have been selected against if mycorrhizae were the major force in natural selection because soil-borne chlamydospores of the mycorrhizal fungi could not possibly have kept pace with air-borne dispersal of seeds (or even sporangia). Germinating seedlings greatly dependent on a mutualistic association would not have survived their new habitats.

Fossilized spores and vesicles discovered by Kidston and Lang (1921) in the Rhynie chert clearly resemble extant species. As Stubblefield and Taylor (1988) argue, however, presence of these structures alone do not denote origin of a mutualistic symbiosis, especially an obligate one. There simply is no evidence that the life cycle of these ancient fungi was identical to that of modern arbuscular species.

Point 3.--Events that led to the first compatible interaction between a plant and its fungal invader cannot be ascertained. One possibility is that host genes responsible for erecting physical and/or physiological barriers against "foreign" biotic or abiotic agents were circumvented by genes in the fungus that produced "host recognizable" components. However, a more complex interaction is envisioned where the genotype of the host also was modified to facilitate compatibility. As an example in a different symbiosis, specific haemoglobin genes have been identified in roots of many nonnodulating plant species (Bogusz et al., 1988). Their expression in the *Rhizobium*-legume symbiosis is considered to be the result of gene modifications during evolution of the highly specialized environment in root nodules.

The competency of host and fungus to maintain the association after the first chance encounter depended on conserving favorable gene combinations in both partners. The symbiosis is hypothesized to have originated on plants that reproduced clonally because asexuality would have maximized fixation of these genes in progeny populations (Vrijenhoek and Lerman, 1982; Harshman and Futuyma, 1985). This hypothesis is plausible because clonal plant groups dominated the landscape during the Devonian Period (Tiffney and Niklas, 1985). The advantages to both partners are persuasive: (i) faithful replication of the advantageous genotype in progeny, (ii) numerical superiority to maximize spread to new habitats, (iii) lower reproductive cost due to transfer of the complete genetic complement, and most important of all, (iv) long-term persistence of the favorable genotypes (Silander, 1985). Under these circumstances, competence of each partner in the developing symbiosis would be strengthened in a self-reinforcing manner as long as fitness and survival improved.

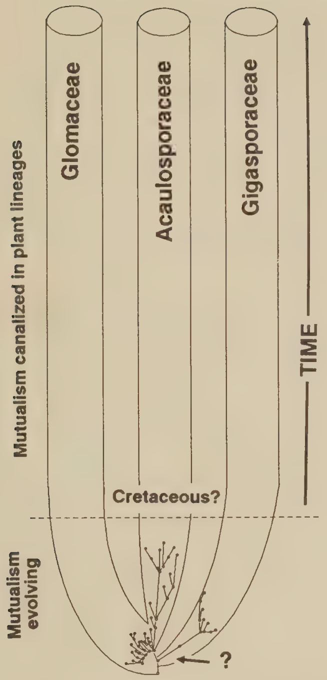


Fig. 7. Depiction of pattern and tempo of speciation by arbuscular mycorrhizal fungi in the three families of the Glomales. Phylogenetic tree is from Morton (1990). The length of each line connecting circles indicates amount of morphological change. A question mark indicates an equivocal decision.

Transformation of this association into one that was mutualistic was more likely to have been gradual rather than saltational in the absence of prolific sexual recombination.

Point 4.--The central question in evolution of the Glomales has to be: When and how did speciation occur? One plausible theory is that of quantum evolution (Simpson, 1953). It presumes that a taxon passes through three phases: (i) an inadaptive phase where the organism loses equilibrium with its ancestor, (ii) a pre-adaptive phase where intense selection pressure leads to a new equilibrium, and (iii) an adaptive phase where this new equilibrium is established and maintained. In this shift from an ancestral to a new "adaptive peak" (= adaptive zone), phenotypic and genotypic changes are likely to be much greater during the period of a shift than before or after that shift. Vrba and Eldredge (1984) argue that origin of species usually involves disruption of characters having primary survival or fitness functions in the ancestor. If these hypotheses are extended to arbuscular fungi, then speciation in ancestral fungal associates probably began in the inadaptive phase when contact was first established with a compatible (but not necessarily mutualistic) plant host. Speciation would likely have been greatest during the pre-adaptive phase when mutualism was evolving.

Co-evolution has long been assumed to occur between mycorrhizal associates (Malloch et al., 1980; Morton, 1990; Nicolson, 1975; Trappe, 1987). However, two processes are involved in these reciprocal interactions: coaccommodation and cospeciation (Brooks, 1979). The former is evident in clones of arbuscular species. The latter could not have occurred because the number of plant species [300,0000; 223,000 of which are angiosperms--Trappe (1987)] far exceeds that of arbuscular species [144 at last count--Schenck and Pérez (1990)]. Law and Lewis (1983) attribute the lower number of fungal species to absence of reciprocal selection forces in the face of positive (selectively advantageous) interactions. The prevailing assumption has been that the fungal symbionts have *continued* to speciate from time of origin to the present day, much like that of plant groups. But what if speciation in fungi began sometime after the Silurian and *ended* before or while angiosperms were emerging in the Cretaceous? The comparison then becomes somewhat less lopsided. Coevolution of host and fungal symbiont would have occurred only during the preadaptive phase of the mutualistic symbiosis if changes in the plant led to reciprocal changes in the fungus to maintain the association and vice versa. Speciation had to have been a consequence of direct selection pressures on the fungal symbiont during its reproductive phase. Under conditions of fluctuating intrinsic and extrinsic biotic and abiotic forces, adaptations in reproductive spores would have been essential to maximize dispersal and survival of fungal genes that preserved the symbiosis. Some spore characters appear to have adaptive value, such as ornamented structural walls to promote dissemination, "endospores" formed by at least one flexible inner wall to mitigate hyperparasitic activity, or carbohydrates in the amorphous inner wall to improve survival or germinability. Other characters have no apparent selective advantage. They could be pleiotropic or neutral additions. These characters would not be lost over millenia if survival or fitness of the fungal symbiont was unaffected and hence would be present in extant taxa.

The large number of species in the Glomaceae (more than the other families combined), presence of some species in an ancient fossil record, and the small amount of morphological divergence between species (Fig. 7) suggest that this family was the first to evolve from a hypothetical progenitor. Speciation in Glomaceae probably was related to rate of development and distribution of gene complexes conferring compatible interactions in early plant groups. During initial stages of the mutualism, clonal reproduction by the progenitor host species would have moderated the extent of morphological change between numerous speciation events. Acaulosporaceae and Gigasporaceae show greater anagenesis (Fig. 7), suggesting that speciation may have occurred later when evolution in plant groups was accelerated by sexual reproduction.

The large difference in morphology of spores in a putative *Glomus* ancestor and those of *Gigaspora* may be due to one of two possibilities: (i) divergence occurred under drastically different host-environmental conditions so that intermediate forms became extinct from species selection (Stanley, 1975) or (ii) evolution from an independent ancestor occurred later in geological time. The purported sexual stage in *Gigaspora* supports the latter hypothesis. The range of morphological diversity in *Gigaspora* is minimal, but it increases substantially if members of *Scutellispora* are considered direct descendants (Morton and Benny, 1990). Sexuality would have afforded *Gigaspora* enough genetic diversity to ameliorate a compatible symbiosis with existing plant genotypes. A shift toward asexual reproduction would fix desirable genes in the fungal symbionts, a phenomenon observed in studies of fish (Vrijenhoek and Lerman, 1982) and geometrid moths (Harshman and Futuyma, 1985). Speciation in *Scutellispora* would continue as long as growth and survival were jeopardized by narrow or incomplete distribution of plant genotypes capable of sustaining the mutualistic symbiosis.

A close look at taxonomic characters distributed within the Glomaceae, Acaulosporaceae, and Gigasporaceae quickly reveals many unique morphological and physiological characters that have little resemblance with those of other zygomycetous fungi (Morton and Benny, 1990). Malloch's (1987) suggestion that the Glomales "represent an evolutionary cul-de-sac, albeit an enormously successful one" is compelling. Extensive morphological divergence could easily derive from unique selection pressures on the fungal partners during evolution of mutualism.

Point 5.--There is no reason to doubt that evolving arbuscular species consisted of morphologically identical clones like those today. Since each clone is isolated reproductively from all others, origin of an evolutionary novelty would not be transmitted through a common gene pool. The new or transformed character that arose

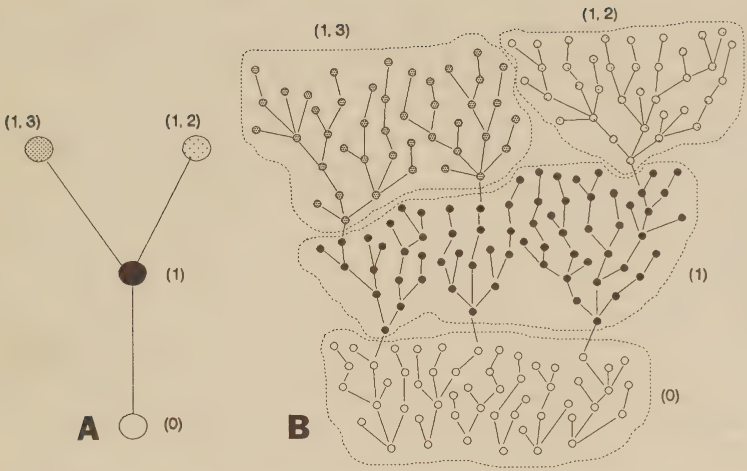


Fig. 8. A. Cladogram depicting pattern of ancestor-descendant relationships between four species of arbuscular fungi; each represented by a circle with different fill pattern. 0 = a species with all plesiomorphic spore morphological characters; 1, 2, and 3 = different evolutionary novelties in spore morphology, each of which defines a descendant species. **B.** Magnification of (A), depicting speciation events among clones within each species; circles of the same fill pattern represent clones of one species; dotted lines indicate species boundaries; lines between circles indicate evolutionary change. Evolution in descendant clones of the same species is measurable only in characteristics of host-fungus interactions, since spore phenotypes are not distinguishable.

in one or more clonal populations (Fig. 8) would be retained as long as it was not maladaptive. Spread of the new "species" (via anagenesis, not splitting of daughter species) would depend on intrinsic (e.g. fecundity, attractiveness to vectors, spore size, density, and arrangement) and extrinsic (e.g. plant distribution and community structure, edaphic conditions) factors surrounding that clone. The final distribution of the new species would depend entirely upon particular host-plant interactions of each clonal subset. Thus, the extent to which arbuscular species, genera, or families are correlated with particular habitats or ecosystems would depend as much, if not more, on *historical* rather than contemporary geological events.

The major gaps in geneological patterns, as denoted by "hypothetical ancestors", were in the early lineages radiating from the common progenitor fungus or during cladogenesis (Morton, 1990). Species extinction may have occurred if clones were localized and plant mortality was extensive. If these ancient entities did not become extinct, then they either have yet to be discovered or they have gone unrecognized among extant taxa. For example, early progenitor species with incomplete development of a mutualistic association would likely have several distinguishable properties: (i) compatible hyphal development in plant roots, (ii) poorly developed or non-existent arbuscules, and (iii) abundant sporulation to offset a tenuous symbiotic association. Species, in fact, do exist which meet these criteria: *G. fecundisporum* Schenck & Smith, *G. leptotichum* Schenck & Smith, *G. occultum* Walker, *G. tortuosum* Schenck & Smith, *A. myriocarpa* Spain, Sieverding & Schenck, and *E. schenckii* Sieverding & Toro. Mycorrhizal structures of these fungi are difficult to detect in stained roots, and no arbuscules or vesicles have been observed except at fungal entry points into host roots (Morton, 1985; Schenck and Smith, 1982; Schenck et al., 1984; Sieverding and Toro, 1987). These species have been given arbuscular status because of similarities in spore structure and absence of pathogenesis in pot-cultured plants.

Point 6.--The most convincing fossils that resemble more complex extant species were found in coal balls from the Pennsylvanian Sub-period (Wagner and Taylor, 1982). These specimens resemble spores of *G. intraradix*, a fungus which is positioned phylogenetically between the most primitive and most advanced lineages in the Glomaceae (Morton, 1990). This fungus also is found on almost every continent (Morton, unpubl.). Assuming an origin in the Pennsylvanian, clones of *G. intraradix* had over 150 million years to spread before the major land masses Laurasia and Gondwana broke apart into continents (Avers, 1989). Some of the most evolutionarily advanced arbuscular species [e.g. *Scutellispora pellucida* Nicol. & Schenck (Walker & Sanders)] are distributed on major continents separated during the Cretaceous. Since spores of these fungi are air-borne for only short distances (Warner et al., 1987), it is possible that origin of these *terminal* species predated the end of the Cretaceous Period (Fig. 7). The presence of an arbuscular symbiosis in all subclasses in the angiosperms (Trappe, 1987) suggests that relevant gene complexes already were canalized by that time.

Ecosystems appear to have evolved in two ways: (i) steady state change resulting from uninterrupted character modifications, speciation, and extinction (Van Valen, 1973) or (ii) evolutionary stasis caused by zero rate speciation and extinction (Stenseth and Maynard Smith, 1984). The fossil record has been invaluable in providing at least some evidence of low rates of divergence in spore (Wagner and Taylor, 1982) and mycorrhizal (Pirozynski and Malloch, 1975; Stubblefield et al., 1987) characters. The low number of gaps in distribution of characters among extant taxa (Morton, 1990) provides circumstantial evidence that putative ancestral species have survived to modern times. More convincing, however, is the presence of species which clearly are ancestral based on cladistic and ontogenetic criteria (Morton, 1990; Morton and Benny, 1990): dimorphic species that link genera (*Glomus* and *Sclerocystis*) and families (Glomaceae and Acaulosporaceae) and species of *Gigaspora* which have no autapomorphies to distinguish them as a sister group of *Scutellispora*.

Asexual recombination generally is considered to favor a high rate of extinction in addition to a low rate of evolution (Williams, 1975). However, asexuality would not be detrimental to species survival if clones could: (i) multiply in diverse environmental conditions and (ii) achieve widespread distribution. One example in the literature is that of the Bdelloidian rotifers (Holman, 1987; Stanley, 1975). They have survived with little divergence since the Paleozoic due to a cosmopolitan existence and resistance to adverse conditions. It can be argued that another example is arbuscular fungi in Glomales. Asexual reproduction provides these organisms with numerical abundance and the ability to persist indefinitely in roots of a broad range of hosts distributed over a wide geographic range. This physiological plasticity to invade the roots of any mycotrophic host provides unsurpassed ecological amplitude. Unlimited growth potential of hyphae in these roots optimize persistence of *clones*. Widespread distribution of clones insures longevity of *species*.

Morphological criteria are reducible only to the species level. They cannot be used to define clonal diversity because phenotypic differences either are not recognizable or they rarely are expressed (Fig. 8). Clonal populations of *Glomus intraradix*, for example, have been cultured at West Virginia University from different plant communities in western, central, southern, and northeastern U.S., Mexico, Brazil, Hawaii, England, and Thailand. Despite the occurrence of these clonal populations in highly heterogeneous environments, *spore characteristics that define them as a species remain consistent*. This is illustrated in representative spores of geographically distant clones of *G. intraradix* and *A. spinosa* in Fig. 1. Similar observations have been made of *G. mosseae* (Nicol. & Gerd.) Gerd. & Trappe, *G. etunicatum* Becker & Gerd., *G. diaphanum* Morton & Walker, *G. occultum*, *G. clarum* Nicol. & Schenck, *Gi. gigantea* (Nicol. & Gerd.) Gerd. & Trappe, and *S. pellucida* clones from different geographic regions (Morton, unpubl.). The most invariant characters are those which have developmental functions. They include type, number, and position of spore walls; events in spore development on *individual* sporophores; and germination processes (Morton, 1988). Epigenetic constraints appear to be substantial in these characters because each step in the developmental process is essential for viable functional mature resting spores. These characters maintain their structure regardless of the environmental fluxes to which the fungal symbiont (and host-fungus complex) are exposed. They were pivotal in specifying ancestor-descendant relationships among genera and families of Glomales (Morton, 1990; Morton and Benny, 1990).

Some developmental characters are known to have varying degrees of phenotypic plasticity (a clonal genotype producing more than one phenotype as a result of changes in the host-soil environment) (Bradshaw, 1965). Most of these characters are involved in events *preceding* severance of physiological ties between spore and vegetative (mycorrhizal) thallus. For example, sporocarp development is a result of spore arrangement and it is highly variable in *Glomus*, depending on undefined conditions during pot culture development (Morton, 1988). The same applies to the proportion of spores of some *Glomus* species to form within or outside roots; occluding mechanisms in *Glomus*; degree of ornamentation on structural walls; spore color, size, shape; thickness of wall types synthesized before spore occlusion; and hyphal diameter and wall thicknesses. The *potential* to achieve a particular character state may be present in the fungal genotype, but development may stop at earlier stages of character transition (e.g. single spores instead of aggregates, aggregates instead of sporocarps) as long as epigenetic constraints are weak.

A number of factors probably contributed to perseverance of species integrity from time of origin to the present day (Fig. 7), but the most dominant of these had to be stabilizing selection of the arbuscular symbiosis. Evolutionary stasis would have occurred *only* after genes optimizing mutualism became canalized in the majority of evolving plant lineages and selection pressures on spores as survival structures was reduced. Maximum exploitation of the root environment of diverse plant genotypes would depend on co-adaptational modifications in the fungus. Selection pressures from changes in physiology, phenology, and morphology of host species would not be of the sort that led to new spore phenotypes. Rather, these evolutionary changes would be expressed in the mycorrhizal phenotypes.

The absence of distinct differences in mycorrhizal anatomy [beyond hyphal width and branching patterns--see Abbott and Robson (1979); Abbott (1982)] has several putative causes. First, the range of anatomical designs for intracellular organs whose function is to interface nutrient exchange between two disparate organisms appears to be fairly narrow. This is reflected in gross similarities between arbuscules, haustoria of plant pathogens, haustoria of biotrophic mycoparasites, and peletons of ericoid mycorrhizae (Harley and Smith, 1983). Strong epigenetic constraints probably limit the amount of morphological divergence that is possible. Other factors also must be involved. Arbuscules are located within a root environment which is not subject to the magnitude of fluxes that warrant major morphological adaptations for survival or fitness (Law, 1985). Similar trends (slower rates of phenotypic transformations) also are exhibited by organisms evolving in marine environments, where conditions are relatively homeostatic compared to those of terrestrial environments (Vrba and Eldredge, 1984). Canalization of host genes regulating the endomycorrhizal association also would inevitably help maintain "conservation of organization" (Stebbins, 1974) in arbuscular from and function.

Point 7.--Arbuscular species are "historical entities" (Wiley, 1980). Their role in contemporary mycorrhizal interactions must be defined by their component parts: clonal populations. Co-adaptation between modern plant species and fungal clones appears to be finely tuned. Selection pressures applied to the larger (and above-ground) plant partner direct genetic changes that can lead to ecotypes or new plant species. This is evident in the continuum of plant dependence on the endomycorrhizal association, from obligate to facultative to nonmycotrophic (Newman and Reddell, 1987; Tester and Smith, 1987; Trappe, 1987). These patterns of mycotrophy indicate that the symbiosis is being selected against in some evolving plant groups and that nonmycotrophic groups are on the rise (Pirozynski, 1981; Trappe, 1987). The mechanisms responsible for this trend are not clearly known, but they appear to differ among plant groups. In some nonmycotrophic hosts, root defense responses are minimal (Tommerup, 1984), suggesting that active resistance mechanisms have not evolved. In other plant species, hypersensitive reactions common to pathogen recognition systems limit colonization by arbuscular fungi (Allen et al., 1989). *Clones* would be susceptible to extinction if they were restricted to habitats containing only nonmycotrophic species, such as those found on disturbed sites in arid portions of the U.S. (Allen and Allen, 1980). *Species* would be jeopardized only if their clonal subunits were restricted to a narrow geographic range with only nonmycotrophic hosts present.

The persistence of clones appears to be underestimated in the literature, particularly when based on counts of extracted spores as sole criterion. Roots continue to be colonized by arbuscular clones when: (i) sporulation ceases under high moisture conditions (Anderson et al., 1984), nutrient levels are high enough so that the host no longer is dependent on the mycorrhizal symbiosis (Habte and Manjunath, 1987), or seasons change (Ebbers et al., 1987; Gemma and Koske, 1988b). The reality is that individual clones can persist in at least a small portion of a root under almost any set of conditions. They can establish a small foothold even in nonmycotrophic hosts (Allen et al., 1989; Tommerup, 1984), particularly if soils are severely deficient in phosphorus (Trinick, 1977).

MICROEVOLUTION

In discussing microevolution, processes and putative causal mechanisms are related *only* to mycorrhizal interactions occurring in obligate to facultative mycotrophic plants. Nonmycotrophic plants do not contribute to microevolution in the fungal symbionts, because macroevolutionary dynamics restrict or exclude a functional association.

Microevolution occurs through processes which exploit the genetic variation present *within* species. Most of this variability probably is generated either through mutation or pleiotrophic genes/gene complexes. In morphologically indistinguishable clones, this variation can be channeled by stochastic (random selection) or deterministic (directional selection) processes. Phenotypic changes that evolve are expressed in *generational phenomena.* Emphasis in research has been on "horizontal" among single-generation "isolates" (= clone or multiclonal populations).

The empirical difficulties with arbuscular species reside in assessing the strength of the connection between genotype and phenotype. No known species are culturable independent of host tissue (Burggraaf and Beringer, 1989) so that vegetative growth characteristics are inextricably coupled with the host phenotype. Only characteristics of spore phenotypes *after* they have become isolated from the fungal thallus directly measure environment and genotype interactions in clonal populations.

Spore Phenotype.--Mechanisms responsible for phenotypic variability are conjectural at this point. The large numbers of nuclei in spores (Burggraaf and Beringer, 1989) may promote canalization of developmental traits (see Point 6 in "Macroevolution") and at the same time serve as a storehouse for mutational variability that can be directed by natural selection *in progeny populations* of individual spores. Pleiotrophic effects of genes involved in mycorrhizal interactions may contribute significantly to phenotypic plasticity of genes not involved in spore development and they could easily obscure boundaries between species. They will be defined clearly only by thorough phenetic analyses under controlled experimental conditions.

Mycorrhizal phenotype.--Ample evidence indicates that the key differences between clones of an arbuscular species reside in morphological and physiological differences of the mycorrhizal phenotype. Component parts of the mycorrhizal phenotype are difficult to measure because complex genotypic interactions between host and fungal partners obscure discrete differences. Fungal characters in the mycorrhizal phenotype include rate, amount, and architecture of external hyphal development; rate, amount, and longevity of arbuscular development; and proportion of hyphae/arbuscules to spores/vesicles (Smith and Gianinazzi-Pearson, 1988; Bowen, 1987). Host characters of the mycorrhizal phenotype include measurements of shoot growth and/or development over time, root architecture, rate and amount of root development, reproductive potential, and physiological parameters (e.g. nutrient concentrations in roots or shoots, photosynthetic or transpiration rates, etc.) (Abbott and Robson, 1984). Several major problems hinder consolidating results of these studies: (i) the impact of soil or edaphic environments on the *same* host-fungus combination has never been examined carefully, (ii) results are generalized at the species level and not at the level of discrete clonal populations, and (iii) many researchers have difficulty recognizing species and clonal distinctions.

Diversity in genotypes of different clones of an arbuscular species appear to be expressed in both host and fungal phenotypes. Differences among clones of the same species have been demonstrated in symbiotic effectiveness (Bethlenfalvay et al., 1989; Haas and Krikun, 1985; Sylvia and Burks, 1988), ability to colonize the same host in different soil environments (Adelman and Morton, 1986; Gildon and Tinker, 1983; Stahl and Smith, 1984), extramatrical hyphae production (Graham et al, 1982), and spore germination (Daniels and Duff, 1978). Inter-clonal variation in these studies was sizable and hence of considerable microevolutionary significance. The particular components of the fungal phenotype affecting differential plant growth responses, however, have never been defined adequately *for specific clonal populations*.

The term "edaphotype" has been introduced to supplant "ecotype" in differentiating disjunct clones of an arbuscular species (Bethlenfalvay et al., 1989). The edaphotype was erected to delineate a clonal from a biological species, but this reasoning presumed that because asexual species lacked a common gene pool, they could not maintain genotypic integrity in the face of microevolutionary change. This assumption has never been put to the test experimentally.

Sexual reproduction enhances the rate more than the amount of genotypic diversity (Williams, 1975). If anything, asexual species, by virtue of mitotic regeneration, fix desirable gene changes faster in progeny populations than do sexual species (Harshman and Futuyma, 1985; Vrijenhoek and Lerman, 1982). The only detrimental effect of asexuality would be increased susceptibility to extinction (Stanley, 1975). However, longevity of clones is bolstered by an indeterminant growth habit and considerable physiological plasticity.

The more significant question which has never been addressed to any satisfaction is: What is the magnitude and plasticity of the linkage between clonal genotype and mycorrhizal phenotype? For example, a clone which is highly effective (relative to other clones) in soybean may be less effective in corn or in a different soil environment. Such results would indicate that the mycorrhizal phenotype was expressed because of a *specific* set of edaphic conditions. Then, the edaphotype concept would be operational. But what if the same clone was consistently effective in different host-soil environments? Then, the same fungal genotype is reflected in a wide range of mycorrhizal phenotypes and the ecotype concept remains valid.

A serious discrepancy in *all* studies of mycorrhizal interactions, including those measuring clonal differences, is the absence of comparisons among generations of clones to assess heritability of characters. Phenotypic stability and rates of genetic change can only be assessed empirically by "vertical" comparisons among generations of isolates. It is in this arena that molecular tools will have considerable impact. Variability among clones ultimately may prove to be as great as that found in multiclonal species of plants and animals (Ellstrand and Roose, 1987).

The question of genotypic stability has practical importance in production and maintenance of inocula, especially if host/edaphic conditions change much between generations of pot (or other) cultures. *In vitro* systems employing transformed roots (Bécard and Piché, 1989) are of particular concern because cultural conditions are highly atypical for the fungal symbiont. Intense selection pressure could significantly alter or modify clonal genotypes. This also is true of pot cultures. Indistinguishable multiclonal populations are likely to exist in heterogeneous host-soil environments commonly found in nature. Only *one* clonal genotype might be selected for when propagated on just *one* host in *one* set of soil conditions.

Most of the evidence suggests that in a tug of war between partners, the fungus loses out. Regulation by the host ranges from degree of mycotrophy to phenomena indicative of more finely tuned interactions. For example, legume roots are heavily colonized, but their nodules are not (Barea and Azcon-Aguilar, 1983); volatile compounds reduce rates of spore germination outside roots of nonmycotrophic plants (Tommerup, 1984) but they enhance germination and chemotropic hyphal growth in mycotrophic plants (Gemma and Koske, 1988a); anatomical features of arbuscules are subject to moderate (Lackie et al., 1987) to extreme (Jaquelinet-Jeanmougin and Gianinazzi-Pearson, 1983) modifications in different host families; and quantity or quality of root exudates can inhibit mycorrhizal development (Graham et al., 1981; Schwab et al., 1984). In all of these instances, *recognition* between host and fungal symbiont does not appear to be affected. Interactions *within* the host that regulate the extent of compatibility in the association are the ones altered significantly.

In the literature, most comparisons of mycorrhizal phenomena are interpreted at too high of a level in the geneological hierarchy. For example, various properties of an arbuscular species have been generalized, either implicitly or explicitly, to encompass *all* clonal populations of that species, even though experimental data usually is limited to one or only a few clonal isolates [see books by Harley and Smith (1983); Powell and Bagjaraj (1984); Safir (1987) for numerous examples]. Such interpretations would have no predictive value, because clonal populations are cohesive only in species-specific (spore) characters that have little meaning in contemporary (mycorrhizal) interactions.

All results ultimately are reducible to genotypic and phenotypic interactions occurring within and among clonal populations. They will have predictive value *only* when explicit comparisons are made at the level of individual clones. This means that the way of doing science must change to meet the *minimum* scientific requirement of voucher specimens (living or dead) to show physical evidence of clonal identity and to provide a reference point for comparison in case the phenotype changes. This practice will insure that an *unequivocal* designation is attached to the isolate and that it is reported *along with the species name* in any research publication. Researchers then will have the means to trace and compare isolates (or results) with a clear understanding of clonal properties. As more clones are characterized, then common properties can be extended upward in the geneological hierarchy to encompass species and possibly even supraspecific taxa.

CONCLUSIONS

Species of arbuscular fungi can be delimited by phenetic and evolutionary criteria that prioritize characters for their value in pinpointing probable speciation events. These events probably occurred during evolution of the symbiosis, when the fungus could not rely on surrounding plants for their growth and survival. Once genes coding for specialized processes interfacing both organisms were widely distributed among most emergent plant lineages, speciation ceased to occur or slowed considerably. Since about the Cretaceous Period, spore phenotypes defining species appear to have remained in a state of evolutionary stasis. Only those characters responsible for co-adaptational changes in mycorrhizal phenotypes continued to evolve in clonal subunits.

All available evidence indicates that microevolution in clones of arbuscular species is uncoupled from processes of speciation and evolution of supraspecific taxa (macroevolution) because of differential selection pressures. Macroevolutionary processes led to emergence of the obligate arbuscular mycorrhizal symbiosis and more extensive speciation in host and fungal partners. They are measurable today by type and extent of change in spore phenotypes. Microevolutionary processes resulted in co-adaptation between arbuscular clones and those hosts having compatible "symbiosis genes". They are measurable today in mycorrhizal phenotypes. Plasticity of the mycorrhizal phenotype is regulated mostly by the host genotype, but the fungal contribution may be highly significant in mycotrophic hosts. The magnitude of this contribution will be discovered only by making comparisons at the clonal level and by including measurements of heritability among generations.

Species-level comparisons are vitally important because they are the window to events in evolution and maintenance of the arbuscular symbiosis. Additional knowledge of diversity in extant taxa will provide a more accurate assessment of evolutionary patterns (anagenic or cladistic). However, knowledge of the properties of species and higher taxa will never be understood clearly without a complete understanding of variability within and among clones. Clonal comparisons will be the stuff that make or break analyses of the role of the arbuscular symbiosis in ecosystems. Predictability of fungal symbionts in the ecological hierarchy will increase *only* as trends of upward causality from clones to species to supraspecific taxa become more clearly defined.

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NOTICE

MYCOTAXON DELIVERY TO FOREIGN COUNTRIES AND CONSEQUENT CHANGES IN PRICES

For many years MYCOTAXON has maintained two prices for subscriptions, a regular rate and a personal rate (the latter offered at under true cost), and no surcharge has been levied for the extra costs of delivery of mail to foreign addresses. This has meant, of course, that US subscribers have been subsidizing the subscription rates of foreign subscribers.

We must now address this problem, since the postal differential is too great. We are forced to add $1.00 per volume to the cost of subscriptions mailed by surface post to Canada and to Mexico, effective immediately, beginning with volume 38.

At the same time we have addressed the long-standing problem of the length of time that surface mail has taken to reach overseas subscribers. This varied from approximately two to three months for European delivery to six months or more for delivery to Australasia, Latin America, South Africa, India, etc. We have now contracted with an international mail forwarder to ship our current issues to overseas subscribers by *air,* with surface delivery *within* their country. This should permit delivery anywhere overseas within 15 days of shipment! The cost of this new air delivery service will result in an increase of $5.00 per volume for overseas subscribers, also effective immediately, beginning with volume 38. We sincerely hope that our subscribers will be pleased with the rapid delivery we are now able to provide.

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TAXACOM-NET INFORMATION SERVICE

The Buffalo Museum of Science (R. H. Zander) and Michigan State University (J. H. Beach) have jointly initiated TAXACOM-NET, an information service for systematic biology which is a network extension of the Buffalo Museum's TAXACOM dial-up service.

TAXACOM-NET consists of three mailboxes which accept mail messages from any network source and then automatically distribute those messages to any biologist who has added his/her name to the mailbox mailing list. This service is capable of reaching biologists on BITNET, Internet, ACSNET (Australia), JANET (United Kingdom), EARN (Europe), or those on any other gatewayed network. Announcements, notes, news, requests, and technical contributions are delivered to network user accounts in the form of mail messages. There are no restrictions placed on participation in the mailing lists, any network user may post a contribution to them, and there is no cost.

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For more complete information please direct your enquiries to J. H. Beach at Michigan State University (BITNET address: jhbeach @ msu; Internet address: jhbeach @ ibm.cl.msu.edu.; telephone (517) 355-4695).

AUTHOR INDEX, VOLUME THIRTY-SEVEN

Adaskaveg, J. E., J. M. Ogawa, and E. E. Butler, Morphology and ontogeny of conidia in *Wilsonomyces carpophilus,* gen. nov. and comb. nov., causal pathogen of shot hole disease of *Prunus* species 275-290
Ahti, Teuvo, see **Hammer and Ahti**
Almeida, Rogério T., and N. C. Schenck, Albino spores associated with dark-spored species of *Scutellispora* 293-295
Andersen, Torben F., A study of hyphal morphology in the form genus *Rhizoctonia* 25-46
Anon., NOTICE: MYCOTAXON delivery to foreign countries and consequent changes in prices 517
Anon., NOTICE: TAXACOM-NET information service 518
Benny, Gerald L., see **Morton and Benny**
Ben-Ze'ev, I. S., see **Tyrrell and Ben-Ze'ev**
Bernicchia, Anarosa, see **Larsen and Bernicchia**
Butler, E. E., see **Adaskaveg & al.**
Crane, J. L., see **Huhndorf & al.**
Currah, R. S., see **Richardson and Currah**
De, A. B., Interfertility studies on three species of Corticiaceae 63-65
Della Lucia, Terezinha M. C., see **Muchovej and Della Lucia**
Diederich, Paul, New or interesting lichenicolous fungi 1. Species from Luxembourg 297-330
Dirig, Robert, Distributional and ecological notes on *Hypocenomyce scalaris* (Lecanorales, Lecideaceae) in eastern North America 441-462
Esslinger, Theodore L., On the correct names for some species of *Melanelia* 401-402
Gams, W., O. Petrini, and D. Schmidt, *Acremonium uncinatum,* a new endophyte in *Festuca pratensis* 67-71
Gilbertson, Robert L., see **Laferrière and Gilbertson**
Goos, R. D., see **Hosagoudar and Goos**
Hammer, Samuel, and Teuvo Ahti, New and interesting species of *Cladonia* from California 335-348
Hanlin, Richard T., *Acerviclypeatus,* a new genus for the anamorph of *Ophiodothella vaccinii* 379-384
Hedger, J. N., see **Kramadibrata and Hedger**
Heykoop, Michel, see **Moreno & al.**
Hjortstam, Kurt, and M.ª Teresa Tellería, *Columnocystis,* a synonym of *Veluticeps* 53-56
Hosagoudar, V. B., and R. D. Goos, Meliolaceae of South India — VII 403-411
Hosagoudar, V. B., and R. D. Goos, Meliolaceous fungi from the State of Kerala, India II. The genus *Meliola* 217-272
Huhndorf, S. M., J. L. Crane, and C. A. Shearer, Studies in *Leptosphaeria.* Transfer of *L. massarioides* to *Massariosphaeria* 203-210
Hyde, K. D., see **Jones and Hyde**
Illana, Carlos, see **Moreno & al.**
Iwatsu, Tokio, and Shun-ichi Udagawa, *Exophiala jeanselmei* var. *castellanii,* a new combination for *Exophiala castellanii* 291-292

Jones, E. B. Gareth, and K. D. Hyde, Observations on poorly known mangrove fungi and a nomenclatural correction 197-201

Kramadibrata, K., and J. N. Hedger, A new species of *Acaulospora* associated with cocoa in Java and Bali (Indonesia) 73-77

Kuthubutheen, A. J., see Nawawi and Kuthubutheen

Laferrière, Joseph E., and Robert L. Gilbertson, A new species of *Albatrellus* (Aphyllophorales: Albatrellaceae) from Mexico 183-186

Laferrière, Joseph E., and Robert L. Gilbertson, A new species of *Polyporus* (Aphyllophorales: Polyporaceae) from Mexico 331-333

Larsen, Michael J., Reexamination of the nomenclatural types of *Polyporus rimosus* Berk. and *P. badius* Berk. 353-361

Larsen, Michael J., and Anarosa Bernicchia, *Lindtneria panphyliensis* sp. nov. from Po Valley, Italy 349-352

Lewis, David P., see Singer & al.

Li, Chao-da, see Zang & al.

Lusk, Demaris E., A new pyrenomycete record for the New World 273

Moravec, Jiří, A taxonomic revision of the genus *Cheilymenia* — 2. *Cheilymenia asteropila* spec. nov. and *Cheilymenia gemella* comb. nov. 463-470

Moreno, Gabriel, Carlos Illana, and Michel Heykoop, Contribution to the study of the myxomycetes in Spain. II 1-24

Morton, Joseph B., Species and clones of arbuscular mycorrhizal fungi (Glomales, Zygomycetes): their role in macro- and microevolutionary processes 493-515

Morton, Joseph B., and Gerald L. Benny, Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): a new order, Glomales, two new suborders, Glomineae and Gigasporineae, and two new families, Acaulosporaceae and Gigasporaceae, with an emendation of Glomaceae 471-491

Muchovej, J. J., and Terezinha M. C. Della Lucia, *Escovopsis*, a new genus from leaf cutting ant nests to replace *Phialocladus* nomen invalidum 191-195

Mueller, Gregory M., and Else C. Vellinga, Taxonomic and nomenclatural notes on *Laccaria* B. & Br. III. *Laccaria amethystina* and *L. impolita* 385-388

Nawawi, A., and A. J. Kuthubutheen, Addition to *Subulispora* from Malaysia 389-393

Nawawi, A., and A. J. Kuthubutheen, New species and combinations in *Vermiculariopsiella* (Hyphomycetes) 173-182

Nawawi, A., and A. J. Kuthubutheen, *Obeliospora*, a new genus of setose, phialosporous hyphomycetes with appendaged conidia 395-400

Ogawa, J. M., see Adaskaveg & al.

Ovrebo, Clark L., see Singer & al.

Pascoe, I. G., *Fusarium* morphology I: Identification and characterisation of a third conidial type, the mesoconidium 121-160

Pascoe, I. G., *Fusarium* morphology II: Experiments on growing conditions and dispersal of mesoconidia 161-172

Petrini, O., see Gams & al.

Richardson, K. A., and R. S. Currah, Myxomycetes of Alberta 363-378

Schenck, N. C., see Almeida and Schenck

Schmidt, D., see Gams & al.

Shearer, C. A., see Huhndorf & al.

Simmons, Emory G., *Alternaria* themes and variations (27—53) 79-119

Singer, Rolf, Clark L. Ovrebo, and David P. Lewis, A new species of

Melanomphalia (Crepidotaceae) 47-52
Tellería, M.ª Teresa, see **Hjortstam and Tellería**
Tyrrell, D., and I. S. Ben-Ze'ev, An emended description of *Furia crustosa* (Entomophthorales: Entomophthoraceae) 211-215
Udagawa, Shun-ichi, see **Iwatsu and Udagawa**
Vellinga, Else C., see **Mueller and Vellinga**
Verdon, Douglas, New Australasian species and records in the genus *Leptogium* S. Gray (lichenized Ascomycotina: Collemataceae) 413-440
Wright, Jorge E., *Calvatia pachyderma* (Peck) Morgan is *Gastropila fragilis* (Lév.) Homrich & Wright 187-189
Yang, Da-rong, see **Zang & al.**
Zang, Mu, Da-rong Yang, and Chao-da Li, A new taxon in the genus *Cordyceps* from China 57-62

REVIEWERS, VOLUME THIRTY-SEVEN

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INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME THIRTY-SEVEN

This index contains the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface,** as are the page numbers on which such new taxa are proposed. New suprageneric taxa are in **BOLD CAPITALS**.

Abrothallus 302
  acetabuli 297, **298**-300
  parmeliarum 298, 302
    f. prodiens 300
  prodiens 297, **300**-302
Acaulospora 73, 471, 473, 475, 479, 480, 482, 485, 488
  appendicula 76, 474, 479, 480, 482, 486
  delicata 75, 76, 480, 482, 486
  dilatata 480, 486
  laevis 480, 482
  myriocarpa 475, 479, 503
  nicolsonii 479
  spinosa 479, 480, 486, 497, 505
  sporocarpia 475, 479
  walkeri **73**, 75, 76
ACAULOSPORACEAE **479**
Acerviclypeatus 379, **380**, 381, 383
  poriformans **381**-383
Acladium 194
Acremonium 67
  sect. Albo-lanosa 67, 70
  chisosum 70
  coenophialum 70
  typhinum 67, 70
  uncinatum 67, **68**-70
Acrocordiopsis
  patilii 198
Aecidium
  peltigerae 312
Aegerita
  physciae 312, 314
Agaricus
  amethysteus 385, 386
  amethystinus 385, 386
  farinaceus 386
  laccatus 385, 386
    var. amethysteus 385
  rosellus 386
Aigialus
  grandis 198
  mangrovis 198
  parvus 198
  rhizophorae 197, 198
Albatrellus 183
  cristatus 183, 185
  mexicanus 183, **184**-186
  pes-caprae 183, 185
Aleurodiscus
  tabacinus 54
Alternaria 79, 80, 84, 86-92, 98, 100, 102, 108-114, 116, 117
  alternata 91-94, 96, 97, 109
  brassicae 109
    f. citri 108-110
  chartarum 90
  citri 79, 80, 84-91, 98, 100, 110-114, 116, 117
  consortiale 90
  fagaricola 116, 117
  hesperidearum 79, **92**, 94-96, 116
  interna 112, 117
  limicola **79-82**, 83, 84, 117
  macalpinei 79, **111**
  pellucida 79, **102**, 103
  'tax. sp. XLI' 80
  tenuis 90, 109, 112, 113
    f. chalaroides 89, 90, 112
    f. prolifera 109
  tenuissima 87, 90, 98-101, 109, 112
  zinniae 80
Amazonia 218, 403, 404
  balakrishnanii 403, **404**, 405
Amblyosporium 194
Aniptodera
  mangrovei 198
Arcyria 2
  affinis 2
  cinerea 2, 367
  denudata 2, 367, 372
  ferruginea 2, 367
  incarnata 2, 367
  nigella 2, 3
  nutans 2, 366, 367
  obvelata 2, 367
  oerstedtii 367, 369
  pausiaca 3
  pomiformis 2, 3, 368
Armatella 218
Arthonia 304
Ascocratera
  manglicola 198, 199
Asteridiella 218
Atkinsoniella
  hypoxylon 67

Badhamia 15
  affinis 3, 372
  armillata 3
  cinerascens 372
  crassipella 14-16
  dearnessii 3, 4
  foliicola 5
  goniospora 3
  gracilis 5
  macrocarpa 3, 372
  orbiculata 3

populina 373
utricularis 5, 373
Bahusutrabeeja 400
dwaya 400
Balansia 67
Bathyascus
avicennae 197, 198
grandisporus 198
Belizeana
tuberculata 198
Biatora
ostreata 443
Biatriospora
marina 198
Bipolaris
sorokiniana 70
Bispora 304
christiansenii 304
lichenum 297, **302**-304
Bjerkandera
adustus 367
Buellia
griseovirens 316
prodiens 300

Calcarisporium 148, 157
Caloplaca
ferruginea 316, 318
Calvatia 187, 188
stirps Pachyderma 187, 188
fumosa
var. fumosa 187
var. idahoensis 187
hesperia 187
pachyderma 187, 188
subcretacea 187
Candelariella
xanthostigma 304
Caryosporella
rhizophorae 198
Catillaria 433
Ceratiomyxa
fruticulosa 5, 364
var. porioides 5
Ceratobasidium
cornigerum 26
ramicola 26
Cercospora 286
Chaetomastia 209, 210
Cheilymenia 463, 468
sect. Cheilymenia 463, 468, 469
asteropila 463-466, 468, 469
ciliata 468, 469
coprinaria 468, 469
crucipila 468
gemella 463, **469**
stercorea 468
var. gemella 469
var. glacialis 469
Chrysothrix
candelaris 323, 326
Cirrenalia
basiminuta 197, 199
Cladonia 335, 336, 341, 442
subg. Cladina 344
sect. Cladonia 335, 336, 341
sect. Clausae 335
sect. Perviae 341
subsect. Cladonia 335, 341
subsect. Thallostelides 335, 341
aleuropoda 338
andesita 338
cervicornis 335, 336, 344-346
subsp. cervicornis 346
chlorophaea 345
conista 345
conistea 345
cornuta 337
subsp. cornuta 337
subsp. groenlandica 335-337
var. groenlandica 337
cyathomorpha 345
dimorpha 335, 336, **339**-341, 344
furcata 341
gracilis 338
subsp. turbinata 344
groenlandica 337
humilis 335, 336, 344-346
var. bourgeanica 345
var. humilis 345
multiformis 341
nemoxyna 338
ochrochlora 337
phyllophora 344
pityrea 341
var. verruculosa 338
prolifica 335, 336, **342**-344
pyxidata 341
ramulosa 341
ravenelii 457, 458
rei 338
thiersii 336
transcendens 336
verruculosa 335, 336, 338
Cladosporium 111
Clasterosporium 275
amygdalearum 284
carpophilum 275, 284, 289
Clitocybe
amethystina 385
Collaria
elegans 5
rubens 5
Collema 435
kaiuense 437
subconveniens 413, 437, 438
subflaccidum 437
Collybia
amethystina 385
Columnocystis 53, 54
africana 54

[Columnocystis] carpatica 55
  pimeriensis 54
Comatricha
  acanthodes 370
  aequalis 371
  irregularis 371
  nigra 6
  rispaudii 370, 373
  typhoides 367, 372
Cordyceps 57, 58, 60
  crassispora 57, **58**, 60, 62
  gunnii 60
  hawkesii 60
  sinensis 57, 58, 60, 62
Cortinarius 385, 386
  traganus 385
Coryneum 275
  beyerinckii 275, 284, 289
  carpophilum 284, 289
  laurocerasi 284
Craterium 6
  aureum 6
  leucocephalum 373
    var. leucocephalum 7
    var. scyphoides 7
  minutum 7, 373
Crepidotus 47, 51
  sect. Echinospori 47, 51
  conchatus 48
  harperi 48
  nyssicola 51
  quitensis 48
  stipitatus 51
  tahquamenonensis 48
Cribraria 364
  argillacea 7, 364
  cancellata 7, 364
  oregana 364
  purpurea 365, 368
  rufa 365
Crustoderma
  opuntiae 64
Cucullispora 199, 200
Cucullospora 197, 199, 200
  mangrovei 200
Cucullosporella 197, **200**
  mangrovei 198, **200**

Dactylaria 157, 391
Deightoniella 286
Dictydium
  cancellatum 364
Diderma
  cinereum 373
  crustaceum 373
  effusum 9
  fragilis 1, 7, 8
  globosum 373
  niveum 370, 373
  platycarpum 1, 9
  radiatum 374
  spumarioides 374
  trevelyani 10
Didymella
  avicenniae 198
Didymium 9
  aquatile 10
  bahiense 10
  clavus 10
  difforme 10, 12
  eximium 10
  melanospermum 10, 11
  minus 11
  muscorum 11
  nigripes 11
  simlensis 11
  squamulosum 6, 11, 374
  trachysporum 11
Dinemasporium
  adeanum 173, 179
  immersum 178
Discosporina 383
Drechslera 70
Drepanocladus
  uncinatus 369

Endogone 471, 473
  pisiformis 473
Enerthenema
  intermedium 12
  papillatum 12
Enteridium
  lycoperdon 12, 365, 366
  splendens 365, 374
Entomophthora
  crustosa 211
Entrophospora 471, 479, 480, 482, 485, 488
  colombiana 480, 486
  infrequens 482
  schenckii 503
Epichloë
  typhina 67
Epithele 53
Epitheleopsis
  bosei 63, 64
Erynia 211
  subg. Neopandora 212
  crustosa 212
Erythromyces 53, **55**
  crocicreas 53, **55**
Escovopsis 191, **192**, 194
  weberi **192**-194
Excipula
  immersa 178
Exophiala 291
  castellanii 291, 292
  jeanselmei 291
    var. **castellanii** 291, **292**
    var. heteromorpha 291
    var. jeanselmei 291

    var. lecanii-corni 291
  mansonii 291, 292

Feltgeniomyces 304
  luxemburgensis 297, 305-**307**
Fomes
  badius 359
  rimosus 356-358
  scaber 356, 357
Fuligo
  cinerea 12
  septica 12, 374
Furia 211, 214
  crustosa 211, 212, 214
Fusarium 121-123, 125, 126, 138, 141, 143, 149, 151, 153, 154, 156-158, 161-163, 169-171
  sect. Arthrosporiella 122, 153, 156-158
  sect. Elegans 123
  sect. Gibbosum 143, 157
  sect. Liseola 122-125, 149, 153, 154, 156-158, 162, 169, 171
  sect. Martiella 123
  sect. Roseum 122
  sect. Spicarioides 123
  sect. Sporotrichiella 122
  acuminatum 135, 165, 169, 170
  anguioides 135, 156, 157
  arthrosporioides 135, 136, 156, 157
  avenaceum 121-123, 125, 126, 128-136, 141, 153, 155-157, 162, 164-168, 170
  camptoceras 122, 154, 157
  chenopodinum 121, 126, 143-147, 153, 156, 157, 163-167, 169
  chlamydosporum 121, 122, 125, 126, 128, 147-150, 153-155, 157, 162, 164-171
  concolor 157
  detonianum 157
  diversisporum 135, 136, 140, 141, 156, 157
  equiseti 147, 154, 163, 165, 169, 170
    var. bullatum 157
  fusarioides 122, 147, 157
  gibbosum 147
  moniliforme 161, 163, 165, 168-170
    var. subglutinans 151
  oxysporum 122, 125, 154, 158, 165, 169, 170
  pallidoroseum 121, 122, 125, 126, 136-141, 153, 154, 156, 157, 162, 164-171
  roseum 121, 163
  sacchari
    var. subglutinans 151
  sarcochroum 157
  scirpi 143, 147, 157, 163
  semitectum 121, 122, 135-141, 152, 155, 157, 162-164, 170
    var. majus 140
  solani 121, 122, 154, 158, 165, 169, 170
  sporotrichioides 121-123, 125, 126, 141-143, 153, 155-157, 162, 164-170
  stilboides 157
  subglutinans 121, 150-153, 155-157, 161, 165-170
  sulphureum 158
  trichothecioides 156
Fuscidea
  viridis 316

Gastropila 187-189
  fragilis 187, 188
Gigaspora 471, 482, 483, 485-488, 502, 504
  decipiens 293, 482, 485, 495
  gigantea 485, 505
  margarita 485, 486
GIGASPORACEAE 483
GIGASPORINEAE 482
Gloeocystidiellum
  porosum 64
  sinuosum 63, 64
GLOMALES 473
GLOMINEAE 474
Glomus 471-473, 475, 476, 479, 480, 488, 502, 504, 505
  aggregatum 475
  ambisporum 293
  canadense 293
  claroideum 479, 486
  clarum 505
  clavisporum 486
  diaphanum 505
  dimorphicum 293
  etunicatum 486, 505
  fecundisporum 293, 503
  fragilistratum 479, 486
  heterosporum 293
  intraradix 475, 476, 479, 486, 497, 504, 505
  leptotichum 503
  mosseae 479, 486, 505
  occultum 496, 503, 505
  tortuosum 479, 486, 503
  vesiculiferum 293
Gyrothrix 180
  cornuta 173, 180, 181

Halosarpheia
  abonnis 198
  cincinnatula 198, 199
  lotica 198
  marina 197-199
  ratnagiriensis 197, 198
  retorquens 198
  viscosa 198, 199
Helminthosporium
  carpophilum 275, 283, 286
Hemitrichia
  clavata 368, 369
  stipitata 368
Heptameria
  massarioides 204
Heterochaete
  delicata 56
Hirsutella 62
  sinensis 60

Hobsonia
  christiansenii 312, 314
Humaria
  alpina 469
  stercorea
    var. aurantiaco-flava 469
    var. glacialis 463, 469
Hydnum
  delicatum 56
Hymenochaete 55
  subg. Veluticeps 53
  archeri 54
  berkeleyi 54
  crocicreas 53, 55
  hispida 56
  innata 55
  setosa 54
  veluticeps 53, 54
Hypocenomyce
  anthracophila 442, 456, 457
  australis 456
  castaneocinerea 456, 457
  friesii 442, 456
  scalaris 441-443, 445-448, 450-452, 454-457, 460
Hypocreopsis 307
Hypogymnia
  physodes 300, 302
Hypoxylon
  oceanicum 197-199

Illosporium 312
  carneum 312
  corallinum 297, 312
Imbricaria
  fuliginosa 401
Irenopsis 218

Laccaria 385, 386
  amethystea 386
  amethystina 385-387
  calospora 386
  impolita 385, **387**
  singeri 387
Lamproderma
  arcyrioides 370
  columbinum 370
Langermannia 189
  gigantea 189
  pachyderma 188
Lanspora
  coronata 198
Lasallia
  pustulata 447
Lawalreea **308**, 310
  lecanorae 297, **308**-310
Lecanora 310
  conizaeoides 316
  expallens 316
  persimilis 308-310
  pulicaris 316
  quercicola 310
  saligna 310
Lecanoropsis 310
Lecidea
  ostreata 442
  prodiens 297, 300
  scalaris 442
Lecidella
  conspurcatosorediosa 305, 307
Leocarpus
  fragilis 13, 374
Leproloma
  vouauxii 304
Leptogium 413, 419, 423, 429, 435, 437
  atro-viride 435
  australe 426-428
  austroamericanum 413, 418, 428
  azureum 413
  biloculare 413, 429, 435, 439
  brebissonii 431, 432
  bullatulum 413, 418, 429
  burgessii 437
  caerulum 435
  carneolum 436
  chloromelum 414-416, 438, 439
    var. victorianum 413, 438, 439
  coralloideum 413, 416, 418, 431
  corniculatum 413, 433
  crispatellum 437
  cyanescens 422
  dactylinum 437, 438
  denticulatum 422, 436
  enkarodes 413, **414**-416, 423
  faciifictum 413, **416**-418, 421, 423
  fallax 413, 433, 434
  inflexum 437
    var. limbatum 413, 436, 437
  isidiosellum 431
  javanicum 416, 419, 420
    var. javanicum 420
    var. microlobum 418, 420
  kilmorense 438
  leptophyllinum 422
  lichenoides 434
  limbatum 413, 436, 437
  marginellum 438
  moluccanum 422
  olivaceum 437
    var. granulatum 437
    var. limbatum 437
  palmatum
    f. fusidosporum 433
  pecten 413, 424-426, 437, 438
  pellobatum 413, 416, **418**-420, 423
  philorheuma 413, 437, 438
  poliophaeum 413, **420**-423
  propaguliferum 422
  rogersii 413, **424**-426
  streimannii 413, 425, **426**-428

  tasmanicum 424, 436, 437, 438
  tremelloides
    var. limbatum 437
    var. muscitegens 413, 438
  urceolatum 436
  victorianum 413, 438, 439
  wilsonii 436
Leptographium 286
Leptosphaeria 203, 204, 311
  doliolum 311
  massarioides 203, 204
  ramalinae 297, 310, 311
Licea
  fimicola 365
  tenera 365
  variabilis 13
Lichen
  cervicornis 345
  humilis 344
Lichenoconium
  xanthoriae 319
Lignincola
  tropica 198
Lindbladia
  tubulina 365
Lindtneria 349, 352
  panphyliensis 349, **350**-352
Lopharia
  crassa 56
Lophiostoma 203, 204
  mangrovis 198
Lycogala
  epidendrum 13, 366-368
  flavofuscum 13, 366
Lycoperdon
  pachydermum 187, 188

Macrosporium 89, 90, 92, 108, 110-112, 116
  citri 79, 84, 86, 87, 89, 90, 110-112, 117
  dictamni 113-115
  disruptum 111
  fagaricola 114, 117
  hesperidearum 92, 116
  internum 112, 117
  rhabdiferum 275, 283
  rosarium 106, 109
  ruticola 108
Marchandiomyces 311
  corallinus 297, 311, **312**-314, 319
Marinosphaera
  mangrovei 198
Massarina
  thalassiae 198
  velataspora 197, 198
Massariosphaeria 203-205, 209
  compositarum 205, 209, 210
  grandispora 209, 210
  massarioides 204-210
  phacospora 209, 210
Melanelia 298, 401, 402
  disjuncta 402
  elegantula 402
  fuliginosa 401
  glabra 401
  granulosa 401
  incolorata 401
Melanomphalia 47, 51
  globulifera 47-**48**, 50, 51
  leucocephala 51
  nigrescens 47
Meliola 217, 218, 220, 222, 225, 226, 229-231, 233, 235, 236, 239, 241-249, 403, 408, 409
  acanthacearum
    var. occidentalis 218
  aglaicola 218
  alstoniae 218
  amoorae 408
  anacolosae 232
  anceps 218
  ancistrocladii 217, **218**, 255
  angiopteridis 219
    var. angiopteridis 219
    var. **indica** 217, **219**, 255
  aphanamixidis 403, **404**, 406
  apodytes 230
  atalantiae 217, **220**, 256
  atylosiae 217, **220**, 256
  bantamensis 222
    var. bantamensis.**37:** 221, 222
    var. **keralensis** 217, **221**, 257
  bataanensis 222
  beilschmiediae
    var. beilschmiediae 222
    var. cinnamomi 222, 223
    var. **cinnamomicola** 217, **222**, 257
  bicornis 221, 227
  buchananiae 223
  buchananiicola 217, **223**, 258
  buteae 223
  callicarpae 244
  campylotricha 230
  cansjerae 224
  cansjericola 217, **224**, 258
  canthi 251
  capensis 243
    var. malayensis 224
  chandleri 224
  chandrasekharanii 217, **225**, 230, 259
  cissampelicola 229
  citricola 226
  citronellae 248
  cladacantha 242
  cladophila 230
  clausenae 217, **226**, 259
  clavulata 226
  clerodendricola 226
    var. micromera 227
  clitoriae 217, **227**, 260
  coilicosa 228
  commixta 228
  connari 228

[Meliola] cookeana 244
  cycleae 217, **228**, 229, 260
  cymbopogonis 229
  densa 229
  dimidiatae 217, 225, **229**, 261
  diospyri 230
  drypeticola 217, **230**, 261
  erycibicola 231
  erycibis 231
  erycibis-paniculatae 217, **231**, 262
  erythropalii 217, **232**, 262
  erythroxylifolii 232
  floridensis 403, 408
  gamellipoda 232
  glochidii 233
    var. glochidii 233
    var. **velutini** 217, **233**, 263
  glochidiicola 233
  glycosmidis 234
  gneti 234
  gregoriana
    var. confusa 245, 246
  groteana 234
  guareiella 410
  hamata 223
  holigarnae 234
  hoyae 250
  hunteriae 217, **234**, 263
  hymenocardiae 231
  indica 235
  ixorae 236
    var. ixorae 235
    var. **macrospora** 217, **235**, 264
  jasminicola
    var. indica 236
  kansieriensia 233
  ligustri 217, **236**, 264
  linderae 237
  linociericola 237
  litseae
    var. **floribundae** 217, **237**, 265
    var. **insignis** 217, **237**, 265
    var. **keralense** 217, **238**, 266
    var. litseae 237, 238
    var. rotundipoda 239
  luvungae 217, **239**, 266
  machili 239
  malabarensis 236, 240
  malacotricha
    var. major 226, 240
  mangiferae 240
  mannii 403, 404, 406, **408**
  memecyli 240
  mucunae 241
    var. **hirsutae** 217, **240**, 267
    var. mucunae 240, 241
  mucunae-acuminatae 241
  nairii 403, 407, **409**
  neolitseae 241
  nephelii
    var. singalensis 241
  nilgirianthii 217, **241**, 267
  nothopegiae 242
  opposita 408
  osyridicola 411
    var. **indica** 403, 407, **410**
    var. osyridicola 410
  osyridis 411
    var. karamojensis 411
  otonephelii 217, **242**, 268
  pogostemonis 243
  premnae 244
  premnicola 217, **243**, 268
  psychotriae 244
  quadrispina 244
  ramosii 244
  rickiana 245
    var. rickiana 245
    var. **zanthoxyli** 217, **245**, 269
  salleana 246
    var. salleana 245, 246
    var. **smilacis** 217, **245**, 269
  sarcostigmae 217, **246**, 270
  scleropyri 217, **247**, 270
  semecarpicola 248
  stemonuri 217, **248**, 249, 271
  symplocicola 249
  tamarindi 249
  tawaoensis 235
  tecleae
    var. toddaliae-asiaticae 249
  telosmae
    var. tylophorae 250
  tenella
    var. atalantiae 220
  themedae 250
    var. **indica** 217, **249**, 271
    var. themedae 249, 250
  tylophorae 217, **250**, 272
  weberae 250
  wendlandiae 217, **251**, 272
  zanthoxyli 245
  zizyphi 251
Merulius
  aureus 64
Metatrichia
  vesparium 13, 365, 368, 369
Metulodontia
  indica 63, 64
Microsporum
  mansonii 292
Modicella 473
Monodictys 110
  glauca 110
Mucilago
  crustacea 14, 375
Mycenastrum
  corium 188
Mycosphaerella 288
Myriogenospora

  atramentosa 67
Myrothecium 307

Nais
  glitra 199
Nawawia
  filiformis 399, 400

Obeliospora 395, 400
  basispira 395-**397**, 399, 400
Ochrolechia
  androgyna 316
Olpitrichum 194
Omphalia
  amethystea 385
Opegrapha
  atra 304
Ophiodeira
  monosemeia 197, 199
Ophiodothella 379, 381
  vaccinii 379, 381, 383
Oramasia 173
  hirsuta 179
    var. cubensis 173, 180
    var. ramosa 173, 180
Ostracoderma 194
Otthia 288

Paecilomyces
  gunnii 60
  hawkesii 60
Pandora 212, 214
  neoaphidis 214
Paradiachea
  rispaudii 370
Paradiacheopsis
  acanthodes 370
Parmelia 298, 302, 401
  subg. Melanelia 298
  acetabulum 298-300
  exasperatula 312
  glabra 401
  granulosa 401-402
  incolorata 402
Passeriniella
  savoryellopsis 199
Peltigera 374, 375
Perichaena
  chrysosperma 14
  corticalis 369
  depressa 14
  minor 14
  pedata 14
  variabilis
    var. pedata 14
Pertusaria 323
  albescens
    var. albescens 316
    var. corallina 316
  amara 316
  ceuthocarpoides 322
  corallina 322, 323
  dealbescens 322
  hemisphaerica 322, 323
  pertusa 316
  pseudocorallina 322
Peziza
  scubalonta 469
  stercorea
    var. gemella 463, 468, 469
Phaeophyscia
  orbicularis 312, 314
Phaeospora 311
  ramalinae 310
Phaeosporobolus
  usneae 297, 315, 316
Phellinus 353
  badius 353, 359, 360
  rimosus 353, 354, 356-360
  scaber 353, **356**
Phialocladus 191, 192, 194
  zsoltii 191, 192, 194
Phoma
  curvispora 310
  fusispora 310
  lecanorae 310
Physarum 377
  albescens 375
  bethelii 375
  bitectum 14, 15
  bivalve 14, 15, 375
  bogoriense 1, 14-16
  cinereum 14, 376
  compressum 3, 16, 376
  contextum 16, 376
  digitatum 377
  leucophaeum 16
  leucopus 376
  luteolum 376
  notabile 376
  nutans 16
  oblatum 377
  pallidum 14
  pusillum 377
  robustum 16
  rubiginosum 377
  serpula 377
  sulphureum 6
  tenerum 377
  tessellatum 377
  vernum 14
  viride 17, 378
Physcia
  adscendens 314
  caesia 312
  tenella 314
Pleospora
  avicenniae 197, 199
Pleurosticta 298
Polycoccum
  innatum 318

[Polycoccum] sporastatiae 318
  tinantii 297, **316**, 317
Polyporus 331, 333
  alveolaris 333
  badius 353, 359
  igniarius
    var. scaber 353-356
  rimosus 353, 354, 356, 357
  tenuiparies 331-333
Polystictus
  badius 359
Porogramme
  crocicreas 55
Pseudodiplodia
  lichenis 310
Pseudofusarium 138, 158
  fusarioides 157
  fusarioideum 138
  purpureum 157
  semitectum 138
Pseudohansfordia 157, 158
Psora
  ostreata 442
  scalaris 442
Psoroma
  leprolomum 433
Puccinia
  coronata 70
Pyrenochaeta
  collematis 319
  xanthoriae 297, **318**, 319
Pyriculariopsis 391

Ramalina 311
  fastigiata 311
Reticularia
  lycoperdon 12
  splendens 365
Rhinocladiella
  mansonii 292
Rhizoctonia 25-27, 29, 35, 41-44
  alpina 41
  anomala 26, 29, 34, 41
  callae 43
  cornigerum 29
  crocorum 25, 26, 34
  gossypii 42
  mucoroides 26
  neottiae 41
  ramicola 29, 34
  repens 26, 29, 43
  solani 25, 26, 29, 34, 41, 42
  stahlii 26, 29
  versicolor 26, 29, 34
Rhizophila
  marina 199
Rosellinia 199
Russuliopsis
  laccata
    var. amethystea 386

Sarawakus
  lycogaloides 273
Scindalma
  rimosus 358
Sciniatosporium
  carpophilum 284
Sclerococcum
  epiphytorum 297, 320-**322**
  sphaerale 322, 323
Sclerocystis 471-473, 475, 488, 504
  clavispora 479
  coremioides 475
Scleroderma 187, 189
Scutellinia
  crucipila 468
Scutellispora 293, 471, 473, 482, 483, 485, 487, 488, 502, 504
  dipapillosa 485
  dipurpurascens 485, 486
  erythropa 486
  gregaria 293, 294
  heterogama 293, 294
  nigra 293, 294
  pellucida 485-487, 504, 505
  verrucosa 293
Scytalidium
  hepiali 60
Selenophoma 308
  catananches 308
Septoria 383
Sistotrema
  brinkmannii 26
Solosympodiella 391
Sparassis
  radicata 64
Sphaeria
  ramalinae 310
  sinensis 58
Sporastatia 318
Sporidesmium
  amygdalearum 275, 282-284
    f. amygdali communis 278
    f. armeniacae 278
Sporothrix 148
Stachybotrys 60, 62
Stemonaria
  irregularis 371
Stemonitis 372
  aequalis 371
  axifera 17, 371
  flavogenita 17
  fusca 17, 371, 372
  splendens 18, 372
    var. splendens 18
    var. webberi 1, 17, 18
  virginiensis 18
  webberi 17
Stemonitopsis 372
  typhina 18, 372

    var. similis 18
Stemphylium 86, 90, 104, 106, 107
  botryosum 106-108
  citri 89, 90, 114
  macrosporoideum
    var. spumarioides 110
  rosarium 79, **106**-109
Stereum
  ambiguum 54
  archeri 54
  carpaticum 55
Stigmella
  platani 278, 287
  platani-racemosae 278, 287
Stigmina 276, 288
  carpophila 278, 282, 284, 288, 289
  compacta 275, 278-279, 282, 288
  platani 275, 278, 282, 284, 288
  planati-racemosae 275, 282, 284
  pulviniformis 275, 278, 282
Strangospora
  pinicola 304
Stromatocrea 307
Subulispora 389, 391, 393
  argentina 393
  longirostrata 389
  malaysiana 389, 391-393
  procurvata 389, 391
Swampomyces
  armeniacus 199
Symphytocarpus
  flaccidus 18
Sympodiella 286
Sympodiophora 157, 158
  venezuelensis 157
Synnematium 62

Taeniolella 326, 329
  chrysothricis 297, **323**-326
  trapeliopseos 297, **326**-328
  verrucosa 326, 329
Thalassogena
  sphaerica 199
Thanatephorus
  orchidicola 41
Thelephora
  abietina 54
  vinosa 56
Thyrostroma 288
  compactum 288
Thyrostromella 288
  myriana 288
Tilachlidium 62
Trametes
  badia 359
Trapeliopsis
  flexuosa 326, 329
Trechispora
  vaga 64
Trematosphaeria
  lignatilis 199
  striataspora 199
Treubiomyces
  pulcherrimus 273
Trichia
  botrytis 18, 19
    var. flavicoma 19
  contorta 18
  decipiens 368, 369
    var. decipiens 19
    var. olivacea 19
  favoginea 369
  flavicoma 1, 19
  persimilis 20
  scabra 369
  subfusca 370
  varia 20, 370
Trichosporum 54
Tubercularia
  rosea 312
Tubifera
  ferruginosa 20, 366
Tulasnella
  fusco-violacea 26

Ulocladium 86, 90, 104, 105
  atrum 90, 104, 105
  botrytis 104-106
  chartarum 91
  consortiale 91
  obovoideum 79, **104**-106

Veluticeps 53-55
  abietina 53, **54**
  africana 53, **54**
  ambigua 53, **54**, 55
  berkeleyi 54, 56
  fusca 56
  heimii 54
  philippinensis 56
  pimeriensis 53, **54**
  pini 54
  setosa 54
  tabacina 54
Vermiculariopsiella 173, 175, 180, 181
  cornuta 173, **181**
  cubensis 173, **180**, 181
  falcata 173, **175**, 181
  immersa 173, 175, 177-181
    var. immersa 173
    var. ramosa 173, 180
  parvula 173, **177**, 181
  ramosa 173, **180**, 181
Vermiculariopsis
  immersa 179
Verticicladiella 286
Vouauxiomyces 302

Wilsonomyces 275, **283**, 288
  carpophilus 275, 276, 278-280, **283**, 286, 288

Xanthochrous
  rimosus 358
Xanthoria
  candelaria 312, 314
  parietina 314, 318, 319
Xanthoriicola
  physciae 307
Xylobolus
  illudens 54

ERRATA, VOLUME THIRTY-SEVEN

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[CONTENTS continued from inside front cover]

NOTICE: MYCOTAXON delivery to foreign countries and consequent changes in prices 517
NOTICE: TAXACOM-NET information service 518

Author INDEX 519
Reviewers 521
INDEX to Fungous and Lichen Taxa 522
Errata 532
Publication Date, MYCOTAXON Volume 36(2) 532

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Vol. XXXVIII July-September 1990

CONTENTS

The new genus *Trappea* (Basidiomycotina, Hysterangiaceae), a segregate from *Hysterangium* .... **Michael A. Castellano** 1
Considerations about *Dictyochaeta*, *Codinaeopsis* and a new genus, *Dictyochaetopsis* .... **Angélica Arambarri and Marta Cabello** 11
New hyphomycetes from Santiago River. III. (Buenos Aires Province, Argentina) ... **Marta Cabello, Cecilia Cazau, and Angélica Arambarri** 15
New hyphomycetes from Santiago River. IV. (Buenos Aires Province, Argentina) ... **Cecilia Cazau, Angélica Arambarri, and Marta Cabello** 21
A rapid, computer-based synoptic key to genera of gilled fungi. **Bryce Kendrick** 27
Contribution to the study of the myxomycetes in Spain. III. Catalogue of myxomycetes of Spain. **Carlos Illana, Michel Heykoop, and Gabriel Moreno** 37
Arguments for diagnoses based on unaltered wall structure. **Joyce Lance Spain** 71
Noteworthy species of *Hypocrea*, *Hypomyces*, and *Thuemenella* (Ascomycetes, Hypocreales) from Wisconsin .... **Alan D. Parker** 77
Type studies in the Polyporaceae – 22. Species described by C. G. Lloyd in *Polyporus* .... **Leif Ryvarden** 83
Ceratocystis ranaculosus, not *Ceratocystis minor* var. *barrasii*, is the mycangial fungus of the southern pine beetle. **T. C. Harrington and P. J. Zambino** 103
A new combination in *Parencoelia* .... **Wen-ying Zhuang** 117
Calycellinopsis xishuangbanna gen. et sp. nov. (Dermateaceae), a petiole-inhabiting fungus from China .... **Wen-ying Zhuang** 121
Amanita salmonescens — a new species from the southeastern United States .... **Rodham E. Tulloss** 125
Additions to the lichen flora of Iceland .... **Eric Steen Hansen** 133
Methods for isolation of *Cantharellus* species, and the synthesis of ectomycorrhiza with *Picea abies* .... **Eric Danell and Nils Fries** 141

[CONTENTS continued overleaf]

ISSN 0093-4666 MYXNAE 38 1-524 (1990)

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[CONTENTS continued from front cover]

The hyphomycete genus *Goidanichiella*. **W. Gams, R. Steiman, and F. Seigle–Murandi** 149

Two new species of *Aphanoascus* (Ascomycotina). **J. Cano, J. Guarro, and L. Zaror** 161

Veronaea constricta, a new hyphomycete from Egyptian soils. **A. F. Moustafa and O. A. Abdul–Wahid** 167

New and noteworthy polypores from Paraná and São Paulo States, Brazil. **Mario Rajchenberg and André A. R. de Meijer** 173

Type studies in *Tylopilus*. IV. Taxa described by Rolf Singer. 1. **C. B. Wolfe, Jr.** 187

Notes on bambusicolous pyrenomycetes. Nos. 1–10. **Ove E. Eriksson and Jing–zhu Yue** 201

Calvatia turneri (Ellis et Everh.) Demoulin et M. Lange, comb. nov., the correct name for *C. tatrensis* Hollós ...... **V. Demoulin and M. Lange** 221

Redescription of *Pandora gloeospora* (Zygomycetes: Entomophthorales) from *Lycoriella mali* (Diptera: Sciaridae) .. **M. W. Miller and C. B. Keil** 227

New or noteworthy discomycetes. 1. Some stromatic fungi on *Alnus* or *Betula* .... **Trond Schumacher** 233

Spores of *Aleurodiscus amorphus* .... **Ilmi Parmasto** 241

Alpine and subalpine fungi of the Cascade Mountains. I. *Hymenogaster glacialis* sp. nov. .... **Efren Cazares and James M. Trappe** 245

Embellisia and related teleomorphs .... **Emory G. Simmons** 251

Taxonomical studies on Ustilaginales. VI. .... **Kálmán Vánky** 267

Culture characteristics of some *Mycena* species. **Roland Treu and Reinhard Agerer** 279

A new *Diploschistes* species (lichenized Ascomycetes, Thelotremataceae) from India .... **Helge Thorsten Lumbsch and Helmut Mayrhofer** 311

The genus *Lalaria* gen. nov.: Taphrinales anamorphosum. **Royall T. Moore** 315

An artificial key to the genera of the Parmeliaceae (Lichenes, Ascomycotina) .... **Mónica T. Adler** 331

New records of *Lactarius* from Mexico and discussion of the known species ... **Leticia Montoya, Gastón Guzmán, and Victor M. Bandala** 349

Ruminomyces elegans gen. et sp. nov., a polycentric anaerobic rumen fungus from cattle. **Y. W. Ho, T. Bauchop, N. Abdullah, and S. Jalaludin** 397

Several noteworthy higher fungi from southern Yunnan, China. **Zhu–liang Yang** 407

Sarcoscypha in North America (Pezizales, Sarcoscyphaceae). **Francis A. Harrington** 417

Taxonomic revision of the genus *Cheilymenia* — 3. A new generic and infrageneric classification of *Cheilymenia* in a new emendation. **Jiří Moravec** 459

Observations on the genera *Asproinocybe* and *Tricholosporum*, and description of a new species of *Tricholosporum* (Agaricales, Tricholomataceae) ... **Gastón Guzmán, Leticia Montoya, and Victor M. Bandala** 485

NOTICE: A new mycological society and an appeal for books and journals . 497

NOTICE: Some forthcoming meetings 498

NOTICE: Appointment of an Editorial Advisory Board 499

[CONTENTS continued on back cover]

MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION
OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

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TABLE OF CONTENTS, VOLUME THIRTY-EIGHT

July-September, 1990

The new genus *Trappea* (Basidiomycotina, Hysterangiaceae), a segregate from *Hysterangium* .... **Michael A. Castellano** 1
Considerations about *Dictyochaeta*, *Codinaeopsis* and a new genus, *Dictyochaetopsis* .... **Angélica Arambarri and Marta Cabello** 11
New hyphomycetes from Santiago River. III. (Buenos Aires Province, Argentina) ... **Marta Cabello, Cecilia Cazau, and Angélica Arambarri** 15
New hyphomycetes from Santiago River. IV. (Buenos Aires Province, Argentina) ... **Cecelia Cazau, Angélica Arambarri, and Marta Cabello** 21
A rapid, computer-based synoptic key to genera of gilled fungi. **Bryce Kendrick** 27
Contribution to the study of the myxomycetes in Spain. III. Catalogue of myxomycetes of Spain. **Carlos Illana, Michel Heykoop, and Gabriel Moreno** 37
Arguments for diagnoses based on unaltered wall structure. **Joyce Lance Spain** 71
Noteworthy species of *Hypocrea*, *Hypomyces*, and *Thuemenella* (Ascomycetes, Hypocreales) from Wisconsin .... **Alan D. Parker** 77
Type studies in the Polyporaceae – 22. Species described by C. G. Lloyd in *Polyporus* .... **Leif Ryvarden** 83
Ceratocystis ranaculosus, not *Ceratocystis minor* var. *barrasii*, is the mycangial fungus of the southern pine beetle. **T. C. Harrington and P. J. Zambino** 103
A new combination in *Parencoelia* ....**Wen-ying Zhuang** 117
Calycellinopsis xishuangbanna gen. et sp. nov. (Dermateaceae), a petiole-inhabiting fungus from China .... **Wen-ying Zhuang** 121
Amanita salmonescens — a new species from the southeastern United States .... **Rodham E. Tulloss** 125
Additions to the lichen flora of Iceland .... **Eric Steen Hansen** 133
Methods for isolation of *Cantharellus* species, and the synthesis of ectomycorrhiza with *Picea abies* .... **Eric Danell and Nils Fries** 141
The hyphomycete genus *Goidanichiella*. **W. Gams, R. Steiman, and F. Seigle-Murandi** 149
Two new species of *Aphanoascus* (Ascomycotina). **J. Cano, J. Guarro, and L. Zaror** 161
Veronaea constricta, a new hyphomycete from Egyptian soils. **A. F. Moustafa and O. A. Abdul-Wahid** 167
New and noteworthy polypores from Paraná and São Paulo States, Brazil. **Mario Rajchenberg and André A. R. de Meijer** 173
Type studies in *Tylopilus*. IV. Taxa described by Rolf Singer. 1. **C. B. Wolfe, Jr.** 187
Notes on bambusicolous pyrenomycetes. Nos. 1–10. **Ove E. Eriksson and Jing-zhu Yue** 201
Calvatia turneri (Ellis et Everh.) Demoulin et M. Lange, comb. nov., the correct name for *C. tatrensis* Hollós ...... **V. Demoulin and M. Lange** 221
Redescription of *Pandora gloeospora* (Zygomycetes: Entomophthorales) from *Lycoriella mali* (Diptera: Sciaridae) .. **M. W. Miller and C. B. Keil** 227

New or noteworthy discomycetes. 1. Some stromatic fungi on *Alnus* or *Betula* . . . **Trond Schumacher** 233

Spores of *Aleurodiscus amorphus* . . . **Ilmi Parmasto** 241

Alpine and subalpine fungi of the Cascade Mountains. I. *Hymenogaster glacialis* sp. nov. . . . **Efren Cazares and James M. Trappe** 245

Embellisia and related teleomorphs . . . **Emory G. Simmons** 251

Taxonomical studies on Ustilaginales. VI. . . . **Kálmán Vánky** 267

Culture characteristics of some *Mycena* species. **Roland Treu and Reinhard Agerer** 279

A new *Diploschistes* species (lichenized Ascomycetes, Thelotremataceae) from India . . . **Helge Thorsten Lumbsch and Helmut Mayrhofer** 311

The genus *Lalaria* gen. nov.: Taphrinales anamorphosum. **Royall T. Moore** 315

An artificial key to the genera of the Parmeliaceae (Lichenes, Ascomycotina) . . . **Mónica T. Adler** 331

New records of *Lactarius* from Mexico and discussion of the known species . . . **Leticia Montoya, Gastón Guzmán, and Victor M. Bandala** 349

Ruminomyces elegans gen. et sp. nov., a polycentric anaerobic rumen fungus from cattle. **Y. W. Ho, T. Bauchop, N. Abdullah, and S. Jalaludin** 397

Several noteworthy higher fungi from southern Yunnan, China. **Zhu–liang Yang** 407

Sarcoscypha in North America (Pezizales, Sarcoscyphaceae). **Francis A. Harrington** 417

Taxonomic revision of the genus *Cheilymenia* — 3. A new generic and infrageneric classification of *Cheilymenia* in a new emendation. **Jiří Moravec** 459

Observations on the genera *Asproinocybe* and *Tricholosporum*, and description of a new species of *Tricholosporum* (Agaricales, Tricholomataceae) . . . **Gastón Guzmán, Leticia Montoya, and Victor M. Bandala** 485

NOTICE: A new mycological society and an appeal for books and journals . 497

NOTICE: Some forthcoming meetings . . . 498

NOTICE: Appointment of an Editorial Advisory Board . . . 499

NOTICE: Forthcoming major editorial changes . . . 500

Author INDEX . . . 501

Reviewers . . . 504

INDEX to Fungous and Lichen Taxa . . . 505

Errata . . . 524

Publication date, MYCOTAXON Volume 37 . . . 524

MYCOTAXON

Volume XXXVIII, pp. 1-9 July-September 1990

THE NEW GENUS TRAPPEA (BASIDIOMYCOTINA, HYSTERANGIACEAE), A SEGREGATE FROM HYSTERANGIUM

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ABSTRACT

The genus *Trappea* (Hysterangiaceae) is segregated from *Hysterangium* by the persistent layer of sterile locules located just within the true peridium in mature sporocarps and its smooth, bacilloid spores. *Trappea darkeri* comb. nov. has a mostly epigeous habit and a white peridium that stains brown to yellowish brown when bruised; *T. phillipsii* comb. nov. commonly fruits in association with rotten wood and has a white peridium that stains pink when bruised. Both occur only in montane forests in the Northern Hemisphere.

INTRODUCTION

The genus *Hysterangium* is characterized by a distinct cartilagenous columella, a gelatinized trama, and a green gleba with hyaline to pale green, smooth or nearly smooth spores. Vittadini (1831) established *Hysterangium* based on three species from Italy with fusoid spores, which under low magnification (≥ 40x) appear smooth but under oil immersion (1000x) are finely verrucose. Vittadini did not mention the presence of a layer of sterile locules at sporocarp maturity. Harkness (1899) described *Hysterangium phillipsii* based on a fungus that had a thick layer of persistent sterile locules located just within the true peridium at sporocarp maturity and smooth, bacilloid spores. Zeller (1939) described *Hysterangium darkeri* to accommodate a fungus that also had a persistent layer of sterile locules at sporocarp maturity and smooth, bacilloid spores but that differed from *H. phillipsii* in structure and thickness of the true peridium and spore size. After studying all taxa designated as *Hysterangium*, I conclude that *Hysterangium darkeri* and *Hysterangium phillipsii* differ significantly from the remainder of the genus and warrant separation into a new genus. The genus *Trappea* is established to accommodate these two species.

MATERIALS AND METHODS

Herbarium names are abbreviated according to Holmgren and Keuken (1974). Anatomical features were described from fresh or rehydrated material mounted in 5% KOH or Melzer's reagent. Color names are in general terms of the author. Spore dimension ranges are based on the measurement of 50 randomly selected spores from the type collection with the anomalous measurements from other collections included.

TAXONOMIC TREATMENT

Trappea Castellano, *gen. nov.*

Basidiomata *hypogaea vel epigaea, globosa vel irregulariter lobata, alba sed interdum celeriter erubescentia vel brunescentia ubi exposita.* ***Peridium*** *interdum evanescens, in crassitie varium, hyphis inflatis.* ***Gleba*** *viridis vel olivacea, loculis sterilibus abundis, loculis vacuis.* ***Columella*** *distincta, dendroidea vel subpercurrens.* ***Sporae*** *laeves, hyalinae vel virides, ellipsoideae vel oblongae.*

TYPUS: *Hysterangium darkeri* Zeller, *leg* Darker 5957 (NY).

BASIDIOMATA hypogeous to epigeous, globose to irregularly lobed, white when fresh and quickly staining pink or brown when exposed. **PERIDIUM** sometimes evanescent, variable in thickness, of interwoven (sometimes inflated) hyphae. **GLEBA** green to olive, with scattered to abundant sterile locules contained in a gelatinized layer located just within the true peridium; locules empty. **COLUMELLA** distinct, dendroid to subpercurrent. **SPORES** smooth, hyaline to pale green, ellipsoid to oblong.

ETYMOLOGY: In honor of James M. Trappe, mentor and friend, for his studies of hypogeous Basidiomycotina and Ascomycotina.

DISCUSSION: The genus *Trappea* is segregated from *Hysterangium* by its formation of a persistent layer of sterile locules located just within the true peridium and its smooth, bacilloid spores. *Trappea* appears phylogenetically intermediate between the Clathraceae and *Hysterangium*.

KEY TO SPECIES OF *Trappea*

True peridium 35–100 (–200) µm thick, evanescent, staining brown to yellowish brown when bruised; spores ellipsoid to oblong, 4–5.5 x 2–3.5 µm ---------------------------- 1. ***T. darkeri***

True peridium 100–350 µm thick, persistent, staining pink when bruised; spores oblong, 3–6 x 1–2 µm 2. ***T. phillipsii***

1. ***Trappea darkeri*** (Zeller) Castellano, comb. nov. Figs. 1-4.

≡ *Hysterangium darkeri* Zeller. Mycologia 31:17–18, Figs. 32, 33; 1939.

Basidiomata 1–6 cm diam, globose to subglobose or irregularly lobed; white at first, becoming buff to pale orange or yellowish brown when bruised, drying buff to orangish brown; surface glabrous to finely pubescent, later polished. **Rhizomorphs** emergent from base of columella, white, single or clustered and branching, 2 cm (or more) x 1 mm at point of attachment. **Gleba** gelatinous, olive to olive brown to bright olive green; KOH olive gray to dark brown; locules empty, globose to irregular, 20–60 x 100–300 (–600) µm. **Sterile Locules** persistent, numerous, contained in a gelatinized layer (up to 1–2 mm thick) adjacent to the true peridium, lined with large pyriform to subclavate cells, 15–26 x 7–10 µm, with clamp connections present at base, stuffed with hyaline, clamped, thin–walled hyphae. **Columella** distinct, up to 8 mm thick near base, typically dendroid and reaching to 2/3 of the sporocarp, occasionally subpercurrent, grey to translucent bluish gray. **Odor** unpleasent, suggesting stinkhorns or gasoline.

Peridium 35–100 (–200) µm thick, mostly of interwoven to subpericlinal, relatively compact, hyaline to yellowish brown, thin-walled, hyphae 2–4 µm in diam, with scattered crystalline particles and occasional areas with thin-walled, hyaline, inflated cells 10–15 (–25) µm in diam; $FeSO_4$ negative, ETOH pale yellow, Melzer's reagent pale brown with a pale yellow margin, KOH pale yellow to golden; clamp connections common on hyphae. **Cystidia** absent. **Trama** variable in thickness, of thin-walled, hyaline, closely interwoven, capitate hyphae 2–6 µm in diam in a gelatinized matrix, sometimes inflated up to 17 µm in diam, contiguous with the layer of sterile locules; clamp connections common on noninflated hyphae. **Subhymenium** of hyaline, thin-walled, closely interwoven hyphae 3–4 µm in diam, sometimes inflated up to 15 µm in diam. **Basidia** thin-walled, hyaline, irregularly cylindrical to clavate, (11-) 17–28 (-30) x 3–7 µm, clamp connections present at base; (4–) 6 (–8) spored. **Sterigmata** ±0.5 µm in length or absent. Crystalline particles scattered within tramal and subhymenial tissues.

Spores sessile or occasionally with a short pedicel, smooth, 4–5 (-5.5) x 2–3 (-3.5) µm, ellipsoid to oblong, with a slightly tapered to truncate point of attachment; walls less than 0.5 µm thick; in KOH hyaline to pale green singly, olive green in mass, in Melzer's reagent hyaline singly, pale olive in mass.

ETYMOLOGY: Latin, *darkeri*, named for the collector of the type, G. D. Darker.

Figs. 1-4. *Trappea darkeri*. Fig. 1. Cross-section of sporocarp; note thick layer of undeveloped gleba containing sterile locules, Trappe 9525 (OSC), photo courtesy of Dr. D. Luoma. Fig. 2. Photomicrograph of gleba; note abrupt interface between fertile and sterile locules, Trappe 9525 (OSC), photo courtesy of Dr. D. Luoma. Fig. 3. Basid-iospores attached to basidia, HS 3204 (OSC, SFU). Fig. 4. Photo-micrograph of a sterile locule; note palisade of basidioles, HS 3204 (OSC, SFU).

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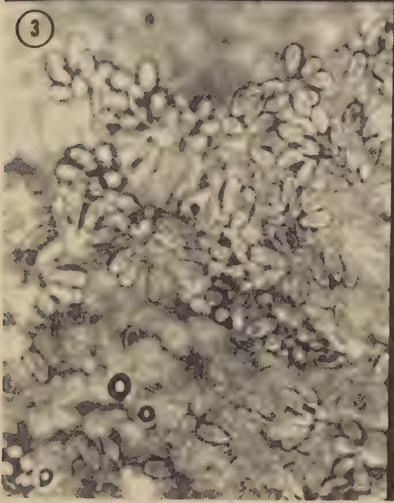
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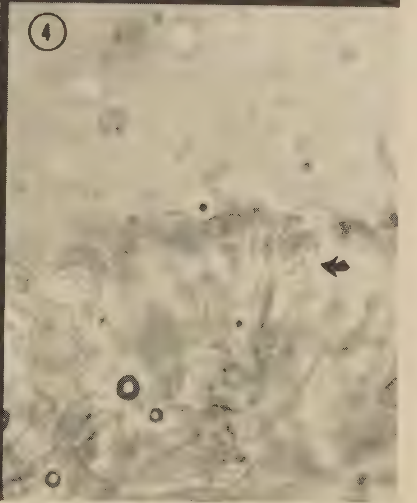
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Distribution, Habitat, and Season: Spain, India, and western North America; epigeous or hypogeous, solitary to scattered; India under *Deodar* in November, Spain in June, in western North America, May through November, presumptively mycorrhizal with *Abies concolor, A. grandis, A. magnifica, A. procera, Picea engelmannii, Pinus contorta, P. ponderosa, Pseudotsuga menziesii,* or *Tsuga heterophylla* usually at elevations of 3000–9600 ft (1000–3100 m).

Discussion: Morphologically *T. darkeri* appears to be closer to *Phallogaster* than to *Hysterangium*. The small, smooth spores and the well-developed columella with attached rhizomorphs indicate placement near *Phallogaster saccatus* Morgan. *Trappea darkeri* is usually found at high elevation in montane forests and commonly fruits at the surface of the ground. Calonge (1982) misidentified a collection of *T. darkeri* from Spain as *Hysterangium membranaceum* Vitt. The Spanish specimen also has slightly larger spores and the pyriform cells of the sterile locules are larger than normal (20-40 µm long x ±13 µm wide). The specimen from India is parasitized, which make peridial characters impossible to distinguish.

Collections Examined: HOLOTYPE: **USA**: **UTAH**: Salt Lake Co., Canyon east of Brighton (Silver Lake), elev. 9600 ft., 3–AUG–1936, leg G. D. Darker 5957 (NY), ISOTYPES (DAOM, FH, NY, OSC). **Other Collections** –– **ALASKA**: Chitina, Wells 6 (MICH). **ARIZONA**: Coconino Co., AHF313, AHF402 (all FSLF). Pima Co., F2180 (MICH, OSC). **CALIFORNIA**: Los Angeles Co., leg Benjamin (OSC); Placer Co., Trappe 3900 (OSC). Humboldt Co., Trappe 4024, 4564 (all OSC). Sierra Co., Thiers 44447, leg Teague, leg Saylor & Thiers, leg Fuller, HS 2095, 2931 (all SFU), Trappe 8077, 8078, 9459, 9525 (all OSC), HS 1494, HS 1956, HS 3204, Trappe 8320 (all OSC, SFU). Shasta Co., Cooke 34138, 34185, (all MICH). Tulare Co., Trappe 7418 (OSC). **COLORADO**: Chaffee Co., F182 (MICH). Clear Creek Co., F194 (MICH). Fraser Co., Kerrigan 1256 (SFU). Garfield Co., F2393 (MICH, OSC). San Miguel Co., F2162 (MICH, OSC). **IDAHO**: Adams Co., O.K. Miller 24 (MICH, OSC). Bonner Co., Smith 68341, 68706, 74217 (all MICH). Boulder Co., Smith 59083 (MICH). Valley Co., Smith 65178 (MICH, OSC). **MONTANA**: Missoula Co., Trappe 3649 (OSC). **OREGON**: Benton Co., Trappe 622, 3712, 3747 (all OSC), Zeller 1849, leg Rogers (all NY). Umatilla Co., leg Rogers (NY). Deschutes

Co., Trappe 9931 (OSC). Coos Co., Trappe 2694 (OSC). Malheur Co., Trappe 4899 (OSC). Linn Co., Trappe 7415 (OSC). Josephine Co., Trappe 7916 (OSC). Jackson Co., F1580 (MICH). **SOUTH DAKOTA**: Pennington Co., F2500, F2501 (all MICH, OSC). **WASHINGTON**: Pend Oreille Co., Smith 68140, 68209, 68237 (all MICH), Watling 3224 (E). **SPAIN**: Guadalajara, leg Calonge (MA2745). **INDIA**: Dehra Dun, leg Bakshi (K). **CANADA**: Alberta, Danielson 2167 (OSC).

2. ***Trappea phillipsii*** (Harkness) Castellano, *comb. nov.*

≡ *Hysterangium phillipsii* Harkness, Cal. Acad. Sci. Proc. III. 1:255, pl. 42, fig. 1. 1899.

Basidiomata 1–4 cm diam, subglobose to irregular, white at first but quickly staining bright pink to pale pinkish brown when bruised; brown in alcohol; base indented. **Rhizomorphs** white when fresh, staining pink when bruised, numerous, branched, attached at base, ± 1 mm thick. **Gleba** soft–gelatinous, dark green to bright green; locules minute, empty. **Sterile Locules** contained in a gelatinized layer (up to 500 µm thick) adjacent to the true peridium, persistent, few to abundant, sometimes contiguous with the peridium, lined with large subclavate cells, 15–26 x 7–10 µm, clamp connections present at base, stuffed with hyaline, thin–walled hyphae; clamp connections present on hyphae **Columella** distinct, translucent, dendroid branching at middle of sporocarp. **Odor** unpleasant, of gasoline.

Peridium 100–350 µm thick, of hyaline, interwoven hyphae 3–5 µm in diam, near the surface the hyphae inflated up to 25 µm in diam, FeSO4 greenish blue grey; clamp connections common on noninflated hyphae. **Cystidia** absent. **Trama** 30–50 µm thick, of hyaline, thin-walled, interwoven hyphae 1–3 µm in diam in a gelatinized matrix. **Subhymenium** of thin-walled, hyaline, interwoven hyphae 2–4 µm in diam, with some cells inflated up to 6 x 9 µm. **Basidia** cylindric, 10–20 x 2–5 µm; 6 (–8) spored. **Sterigmata** inconspicuous.

Spores subsessile, smooth, 3–6 x 1–2 (-2.5) µm, oblong; in KOH hyaline singly, pale green in mass, in Melzer's reagent hyaline singly, pale olive in mass.

ETYMOLOGY: Latin, *phillipsii*, in honor of the collector of the type, C. L. Phillips.

DISTRIBUTION, HABITAT, AND SEASON: California, usually solitary on or in rotten wood, presumptively mycorrhizal with *Pseudotsuga menzeisii, Pinus ponderosa, Abies concolor*, *Abies magnifica var. shastensis* and possibly *Quercus* spp. at elevations of 2000–8000 ft (600–2400 m); January to September.

DISCUSSION: Specimens cited by Zeller & Dodge (1929) from Ohio proved to be *Phallogaster saccatus* Morgan (Zeller 1939). *Trappea phillipsii* is not as frequently encountered as *T. darkeri* and is easily distingushed from it in the field by the distinct pink staining reaction of the peridium when bruised, the peridium of *T. darkeri* stains brown when bruised; microscopically *T. phillipsii* has a persistent and thicker true peridium and slightly longer spores on the average than *T. darkeri.*

COLLECTIONS EXAMINED: HOLOTYPE: **CALIFORNIA**: Placer Co., Wire Bridge, JAN–1899, leg C. L. Phillips, Harkness 234 (BPI). **OTHER COLLECTIONS** — **CALIFORNIA**: El Dorado Co., Trappe 8427 (OSC). Humboldt Co., Parks 4124 (UC). Los Angeles Co., CAHF35 (OSC, FSLF). Marin Co., Parks 3046, 3051 (all UC). San Bernardino Co., Trappe 6734 (OSC), CAHF22 (OSC, FSLF). Santa Clara Co., Gilkey 1064 (OSC). Shasta Co., Cooke 13263, 15679 (all NY). Yuba Co., Thiers 28931 (OSC, SFU). **NEVADA**: Clark Co., F2767 (OSC, MICH). **OREGON**: Deschutes Co., Stewart 60 (OSC).

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Ottawa, Canada (DAOM), University of Edinburgh, Scotland (E), Farlow, Harvard (FH), Kew, England (K), Real Jardín Botánico, Madrid, Spain (MA), University of Michigan (MICH), New York Botanical Garden (NY), Oregon State University (OSC), and University of California (UC).

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MYCOTAXON

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CONSIDERATIONS ABOUT DICTYOCHAETA, CODINAEOPSIS AND A NEW GENUS: DICTYOCHAETOPSIS.

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INTRODUCTION

In a previous research on phenetic relations between some phialidic Hyphomycetes (Arambarri & Cabello, in press) we found that the genera were clearly grouped in two clusters: one of them constituted by those species that have the conidiogenous cells integrated to the conidiophore and the other with those that have phialides that arise laterally on the conidiophore.

In that research we also found that 7 species of Codinaea and one of Dictyochaeta appeared in the second cluster separated from the remaining species because they have lateral conidiogenous cells. For that reason we did not consider them in the genus Dictyochaeta.

The genus Dictyochaeta was erected by Spegazzini in 1923 and it is considered as an earlier name for Codinaea Maire (1937) (Gamundí et al. 1977). The type species is D. fuegiana Speg. and it was originally described with sterile setae accompanied by shorter fertile hyphae and curved, hyaline, non septate, non setulate conidia.

In Dictyochaeta the conidiogenous cells arise terminaly and singly on simple conidiophores, in several species setae are absent. In 7 species of Codinaea and in D. menisporoides Holubová-Jechová, the conidiogenous cells arise on short branches on the conidiophore. Morgan Jones (1976) and Holubová-Jechova (1984) considered them as a particular kind of species of Codinaea.

A genus related with those species of Codinaea that have conidiogenous cells on branches is Codinaeopsis. This genus was established for Codinaea gonytrichoides Shearer & Crane by Morgan Jones (1976). In Codinaeopsis the phialides are borne terminally and laterally on the collar hyphae and encircling a central setose stipe at intervals.

The aim of this paper is to consider the redisposition of 7 species of Codinaea and Dictyochaeta menisporoides in a new genus Dictyochaetopsis.

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TAXONOMIC PART

Dictyochaetopsis gen. nov.
Deuteromycotina, Hyphomycetes.
(Etym. Dictyochaeta et Gr. opsis, aspect)

Conidiophora macronemata, mononemata, setiformia, erecta, recta vel subrecta, laevia, brunnea, septatae, steriles apicem versus attenuatae, fertiles (cum phialide vel polyphialidae). Cellulae conidiogenae monophialidicae vel polyphialidicae, discretae, aut rarius integratae, haud multum infra conidiophorum vel ramorum a latera positae, pallide brunneae; latis collarettis infundibuliformibus praeditae. Conidia agglutinata, falcata, hyalina, 0-vel pluri septata, cum vel haud longis setulis ad apices praedita.

Species typica: Dictyochaetopsis apicalis (Berk. & Curt.) Arambarri & Cabello.

Conidiophores macronematous, setiform, erect, straight or slightly flexuose, smooth, septate, brown, fertile or sterile at the apex. Conidiogenous cells usually monophialidic or polyphialidic, discrete or rarely integrated, borne on the conidiophore or lateral branches, paler than conidiophore, with a funnel-shaped collarette. Conidia aggregated in slimy heads, falcate, 0-multi septate, smooth, hyaline, with or without a long setula at each apex.

Dictyochaetopsis apicalis (Berk. & Curt.) Arambarri & Cabello comb. nov.

=Menispora apicalis Berk. & Curt. apud Berk. Grevillea 3: 146. 1875.

=Codinaea apicalis (Berk. & Curt.) Hughes & Kendrick, N. Z. Jl. Bot. 6: 332, 1968.

We chose D. apicalis as a type species because it is the oldest species of the group.

Other species of the genus Dictyochaetopsis.

Dictyochaetopsis dingleyae (Hughes, Kendrick & Shoemaker) Arambarri & Cabello comb. nov.

=Codinaea dingleyae Hughes, Kendrick & Shoemaker, N. Z. Jl. Bot. 6: 343-346, 1968.

Dictyochaetopsis elegantissima (Lunghini apud Lunghini, Rambelli & Onofri) Cabello & Arambarri comb. nov.

=Codinaea elegantissima Lunghini apud Lunghini, Rambelli & Onofri, Mycotaxon 14(1): 116-118, 1982.

Dictyochaetopsis filamentosa (Onofri apud Lunghini, Rambelli & Onofri) Arambarri & Cabello, comb. nov.

=Codinaea filamentosa Onofri apud Lunghini, Rambelli & Onofri, Mycotaxon 14(1): 120-122, 1982.

Dictyochaetopsis glauco-nigra (Cooke & Ellis) Cabello & Arambarri comb. nov.

=Menispora glauco-nigra Cooke & Ellis. Grevillea 7: 39, 1878.

=Menispora fairmanae Sacc. Ann. Mycol. 10: 314, 1912.

=Codinaea glauco-nigra (Cooke & Ellis) Hughes & Kendrick. N. Z. Jl. Bot. 6: 349, 1968.

Dictyochaetopsis intermedia (Rambelli apud Lunghini, Rambelli & Onofri) Arambarri & Cabello comb. nov.

=Codinaea intermedia Rambelli apud Lunghini, Rambelli & Onofri. Mycotaxon 14(1): 118-120, 1982.

Dictyochaetopsis maharashtrensis (Pirozynski & Patil) Cabello & Arambarri comb. nov.

=Codinaea maharashtrensis Pirozynski & Patil, Can. J. Bot. 48: 567-581, 1970.

Dictyochaetopsis menisporoides Holubova-Jechová) Arambarri & Cabello comb. nov.

=Dictyochaeta menisporoides Holubová-Jechova, Folia Geobot. Phytotax. 19: 430-432, 1984.

DISCUSSION

The genus *Dictyochaeta* was described by Spegazzini (1923) as follows: *"Hyphae olivaceae repentes superficiales rectiusculae reticulato-anastomosantes, septulatae pellucidae, steriles, hinc inde, ad anastomoses praecipue, setulis erectis rectis atris subopacis simplicibus armatae; hyphae fertiles circa bases setularum exsurgentes, breviusculae graciles simplices pallidae septulatae, articulo supremo parum crassiore, conidia linearia acuta continua hyalina gerentes."*

Codinaea was described by Maire (1937) as follows:*"Hyphae externae dimorphae; steriles longissime rectae erectae, obscure brunneae, simplices; fertiles breviores, dilute brunneae, pauciseptatae, flexuosae, apice conidia in capitulum depauperatum disposita, hyalina, apice ciliata gerentes. Ab affini Ellisiella recedit hyphis conidiferis elongatis septatis; conidiis capitulatis. A Myxotrichella differt hyphis sterilibus haud ramosis, hyphis fertilibus liberis (nec in steriles insertis) et coniidis ciliatis."*

Hughes & Kendrick (1968) redescribed the genus *Codinaea* Maire, extending the generic concept, but they did not emend it, including in it *Codinaea apicalis* and *C. glauco-nigra*, that were **redisposed** previously in the genus *Menispora* and erected *C.* state of *Chaetosphaeria dingleyae*, but they differ from all the other species of *Dictyochaeta* by having lateral phialides sessile or borne on branches. Due to these characters these species are far from the original description of the genus but could be included in it on account the broad generic concept by Hughes & Kendrick (op. cit.).

When Shearer & Crane (1971) erected the species *Codinaea gonytrichoides* they considered that it differed from the remaining species of *Codinaea* in its "gonytrichum-like" method of branching and phialide development.

Lunghini et al. (1982) considered that the diagnosis of the genus *Codinaea* was sufficiently complete in its descriptions of characteristics to include all the species described in this genus, and to include *C. gonytrichoides* and the three species described by them: *C. elegantissima*, *C. intermedia* and *C. filamentosa*.

Nevertheless, Morgan Jones (1976) erected the genus *Codinaeopsis* in order to redispose *C. gonytrichoides* since he considered as a very particular form the disposition of the conidiogenous cells borne terminally and laterally encircling hyphae (collar hyphae).

Pirozynski & Patil (1970) described C. maharashtrensis following the treatment of this genus by Hughes & Kendrick (op. cit.), and related it with C. assamica on account of the morphology of setae.

Holubová-Jechová (1984) described Dictyochaeta menisporoides, and considered that this species can not match with Codinaeopsis because the lateral phialides on fertile setae have not the appearence of collar hyphae; for this reason she placed the species in Dictyochaeta and related it with all the species that we are redisposing.

These species are also closely related with Menispora by the phialides arising laterally on the conidiophores. However they differ from Menispora by the lack of the uncinate conidiogenous cells, and the presence of conspicuous collarettes.

Dictyochaetopsis is a genus closely related with Codinaeopsis, Dictyochaeta (=Codinaea) and Menispora.The justification for erecting a new genus for it is therefore evident.

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NEW HYPHOMYCETES FROM SANTIAGO RIVER. III. (BUENOS AIRES PROVINCE, ARGENTINA).

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SUMMARY

In the course of our research on Hyphomycetes from Santiago river (Argentina) we found several species belonging to the genus Sporidesmium Link: Fr. Three of these have been described in previous papers (Arambarri et al. 1987, 1989). In this paper we include four new species namely: S. calyptratum, S. filirostratum, S. longisporum and S. spegazzinii, and two new records for our country namely S. aturbinatum (Hughes) Ellis and S. pedunculatum (Peck) Ellis.

These species were found on decaying wood floating in polluted water from Santiago river which constitute a new habitat for species of this genus

SPORIDESMIUM ATURBINATUM (HUGHES) ELLIS.

(Fig. 1-2)

Ellis, M.B. Mycological Papers 70: 49-50. 1958.

=Podoconis aturbinata Hughes, The Naturalist, London Nº 864: 122. 1953.

Mycelium mostly inmersed in the substratum, composed of branched, septate, subhyaline to brown, smooth walled, 1-3.5 um thick hyphae. Conidiophores arising singly or in groups of 2-3, erect, simple, straight or flexuous, tapering towards the apex, swollen at the base, brown, septate, with percurrent proliferations, 60-150 um long, 4-6 um thick. Conidia formed singly at the apex of the conidiophore which after the first conidium has fallen sometimes proliferates through the scar and forms another conidium at the apex of the proliferation, straight or slightly curved, obpyriform or conical, often 3-septate, occasionally 4-septate, lower cells usually verrucose and dark brown, upper cells smooth and pale brown or subhyaline, 20-30 um long, 7-10 um thick in the widest part tapering to 3-4 um near the apex.

Material examined: ARGENTINA, Buenos Aires, Río Santiago, leg. Cazau VIII-1989. LPS 44613.

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SPORIDESMIUM CALYPTRATUM sp. nov.

(Fig. 3-4)

Mycelia superficiale ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2-4 um crassi compositum. Conidiophora macronemata, mononemata, erecta, simplicia, atrobrunnea, pauciseptata, 30-50 x 6-7 um ad basim et 4-5 um ad apicem, interdum per 1-3 proliferationes succesivas elongascentia. Cellulae conidiogenae monoblasticae, integratae, lageniformis. Conidia singula in apice conidiophori oriunda, recta vel curvata, obclavata, rostrata, ad basim conico truncata, 12-15 seudoseptata, laevia, 60-90 um longa, 9-12 um crassa, atrobrunnea ad basim, sursum pallidiora, apice pileo gelatinoso hyalino praedita.
Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus LPS 44612.
Etymology: from Latin calyptratus, bearing a calyptra or cap-like covering.

Mycelium superficial composed of a network of branched and anastomosing, septate, pale brown, smooth walled, 2-4 um thick hyphae. Conidiophores macronematous, mononematous, erect, simple, dark brown, with few septa, 30-50 x 6-7 um at the base and 4-5 um at the apex, often with 1-3 percurrent proliferations. Conidiogenous cells monoblastic, integrated, lageniform. Conidia formed singly at the apex of the conidiophore, straight or curved, obclavate, rostrate, conic-truncate at the base, 12-15 pseudoseptate, smooth-walled, 60-90 um long, 9-12 um thick in the widest part, dull to dark brown becoming paler near the apex where it is hyaline and with a conspicuous, subglobose, gelatinous cup; often it may have two gelatinous cups that are formed from the outer wall.

This species is completly different from all the others the genus because the outer wall is torn and the gelatinous material comes from within and is not laid over the end of the conidia such as happens in the other species with a gelatinous cup.

SPORIDESMIUM FILIROSTRATUM sp. nov.

(Fig. 5)

Mycelium superficiale ex hyphis ramosis, septatis, pallide brunneis, laevibus, 1-4 um crassis. Conidiophora macronemata, mononemata, erecta, simplicia, atrobrunnea, septata, 15-30 x 4-5 um ad basim et 2-3 um ad apicem. Cellulae conidiogenae monoblasticae, integratae, cylindricae. Conidia singula in apicem conidiophori oriunda, recta vel curvata, obclavata, rostrata, apice acuta, ad basim conico-truncata, laevia, 5-8 pseudoseptata, 85-100 um longa, 8-9 um crassa, apicem versus ad 1-3 um attenuata, basi 3-4 um lata, cellulis basalibus atrobrunneis, cellulis apicalibus graditun pallidioribus.
Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus

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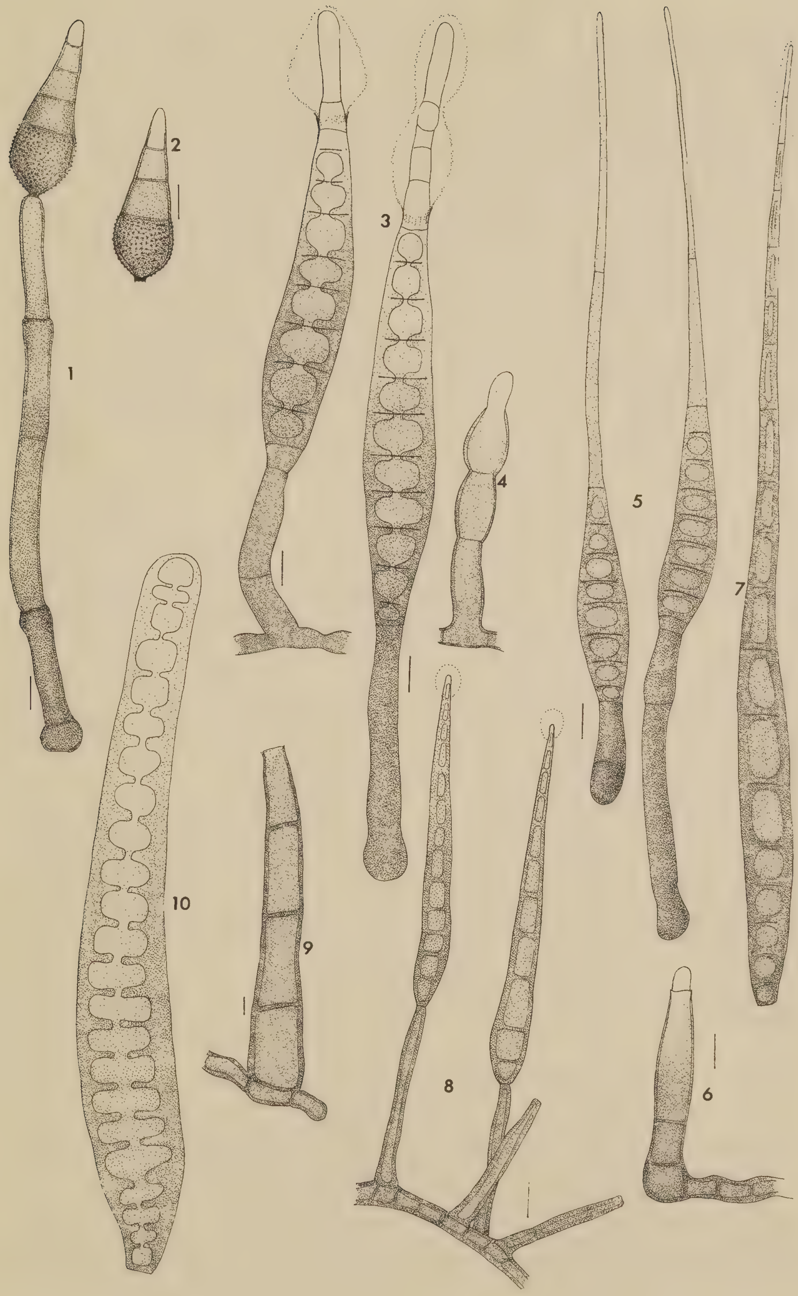
SPORIDESMIUM ATURBINATUM. 1. Conidiophore and conidium, 2. Conidium.
SPORIDESMIUM CALYPTRATUM. 3. Conidiophore and conidium, 4. conidiophore showing percurrent proliferation.
SPORIDESMIUM FILIROSTRATUM. 5. Conidiophore and conidium.
SPORIDESMIUM LONGISPORUM. 6. Conidiophore, 7. Conidium.
SPORIDESMIUM SPEGAZZINII. 8. Conidiophores and conidia.
SPORIDESMIUM PEDUNCULATUM. 9. Conidiophore, 10. Conidium.
Bar indicates 5 um.



LPS 44618.
Etymology: from Latin filum thread; rostratum referring to the long appendage of the conidium.

Mycelium superficial composed of a network of branched and anastomosing, septate, pale brown, smooth walled,1-4 um thick hyphae. Conidiophores macronematous, mononematous, erect, simple, dark brown, septate, 15-30 x 4-5 um at the base, 2-3 um at the apex. Conidiogenous cells monoblastic, integrated, cylindrical. Conidia formed singly at the apex of the conidiophore, straight or curved, obclavate, rostrate, with an acute apex, conic-truncate at the base, dark brown, 5-8 pseudoseptate, 85-100 um long, 8-9 um thick in the widest part, tapering to 1-3 um near the apex, 3-4 um wide at the base. The conidia have a long rostrum, one septate, becoming paler near the apex.

Our species is closely related to S. brachypus (Ellis & Enev.) Hughes (Ellis, 1971) and S. longirostratum Ellis (Ellis, 1958) but differs from these species by the size of the conidia.

SPORIDESMIUM LONGISPORUM sp. nov.
(Fig. 6-7)

Mycelium superficiale ex hyphis ramosis, septatis, pallide brunneis, laevibus, 1-4 um crassis compositum. Conidiophora macronemata, mononemata, erecta, simplicia, atrobrunnea, pauciseptata, 40-50 x 4-6 um ad basim et 3-4 um ad apicem. Cellulae conidiogenae monoblasticae, integratae, lageniformes. Conidia singula in apice conidiophori oriunda, recta vel curvata, obclavata, rostrata, ad basim conico truncata, 13-15 pseudoseptata, laevia, 70-140 um longa, 6-7 um crassa, apicem versus ad 2-2.5 um attenuata, basi 4-5 um lata, cellulis basalibus brunneis, cellulis apicalibus gradatim pallidioribus.
Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus LPS 44617.
Etymology: from Latin longus: long and sporum: spore.

Mycelium superficial composed of a network of branched and anastomosing, septate, pale brown, smooth walled, 1-4 um thick hyphae. Conidiophore macronematous, mononematous, erect, simple, dark brown, with few septa, 40-50 x 4-6 um at the base and 3-4 um at the apex. Conidiogenous cell monoblastic, integrated, cylindrical. Conidia formed singly at tha apex of the conidiophore, straight or curved, obclavate, rostrate, conic-truncate at the base, 13-15 pseudoseptate, smooth walled, 70-140 um long, 6-7 um thick in the widest part, 2-2.5 um at the tip and 4-5 um thick at the base, dull brown to brown becoming paler near the apex.

SPORIDESMIUM SPEGAZZINII sp. nov.
(Fig. 8)

Mycelium superficiale ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2-7 um crassis compositum. Conidiophora macronemata, mononemata, erecta, simplicia, atrobrunnea, pauciseptata, 25-40 x 4-5 um ad basim et 2-3 um ad apicem. Cellulae conidiogenae monoblasticae, integratae, cylindrica. Conidia singula in apice conidiophori oriunda, recta, cylindrica vel obclavata, ad basim conico-truncata, 10-13 pseudoseptata, laevia, 60-70 um longa, 5-7 um crassa, brunnea ad basim sursum pallidiora, apice pileo gelatinoso, hyalino praedita.

Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus LPS 44615-44616.
Etymology: in honour of Carlos Spegazzini.

Mycelium superficial, composed of a network of branched and anastomosing, septate, pale brown, smooth walled, 2-7 um thick hyphae. Conidiophores macronematous, mononematous, erect, simple, dark brown with few septa, 25-40 x 4-5 um at the base. Conidiogenous cell monoblastic, integrated, cylindrical. Conidia formed singly at the apex of the conidiophore, straight, cylindrical to obclavate, conic-truncate at the base, 10-13 pseudoseptate, smooth walled, 60-70 um long, 5-7 um thick in the widest part, brown becoming paler near the apex where it is hyaline and with a small, globose, gelatinous cup.

Our species is closely related to _S_. _fusiforme_ Nees: Fr. but differs by the size of the conidia and by the presence of the gelatinous cup.

SPORIDESMIUM PEDUNCULATUM (PECK) ELLIS.

(Fig. 9-10)

Ellis, M.B. Mycological Papers 70: 67-68. 1958.

=_Claterosporium_ _pedunculatum_ Peck, 25th Report of the State Museum, New York: 93, 1873.

=_Helminthosporium_ _pedunculatum_ (Peck) House, Bull. New York State Museum, 219-220: 234, 1920.

Helminthosporium _attenuatum_ Cooke & Peck 29th Report of the State Museum, New York: 50, 1878.

Mycelium mostly inmersed in the substratum, but occasionally partly superficial, composed of branched, septate, brown to dark brown, smooth walled, 1-4 um thick hyphae. Conidiophores macronematous, mononematous, erect, simple, dark reddish-brown to black, 3-10 septate with up to 5 successive proliferations, 40-100 um long, 6-8 um at the base, 4-5 um at the apex. Conidiogenous cell monoblastic, integrated, cylindrical. Conidia formed singly at the apex of the conidiophore, straight or curved, obclavate, conic-truncate at the base, smooth walled, rather dark reddish-brown, apical cell often subhyaline, 9-26 pseudoseptate, 80-110 um long, 11-15 um in the widest part, usually tapering to 5-7 um thick.
Material examined: ARGENTINA, Buenos Aires, río Santiago, leg Cazau VI-1989. LPS 44614.

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MYCOTAXON

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NEW HYPHOMYCETES FROM SANTIAGO RIVER. IV. (BUENOS AIRES PROVINCE, ARGENTINA).

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INTRODUCCION

Furthering our research on *Hyphomycetes* growing on organic material floating in Santiago river we found several species belonging to the genus *Dactylaria* Sacc. The main character of this genus is the presence of hyaline or subhyaline, thin-walled, 1-several septate conidia on sympodially proliferating brown or hyaline conidiophores; two species having rostrate conidia, formed by the extension of the outer wall were found, but this character does not warrant a new genus. We described two species of *Dactylaria* in previous papers (Arambarri et al. 1988 and Arambarri & Cabello, in press), and two additional new species are described here, namely: *D. appendiculata* sp. nov. and *D. longidentata* sp. nov. We propose a new combination: *D. argentina* (Arambarri & Mengascini) Cabello & Cazau whereas *Dactylaria parvispora* (Preuss) de Hoog & von Arx, *Mirandina breviphora* Matsushima and *M. corticola* Arnaud ex Matsushima are a new record for our country.

DACTYLARIA APPENDICULATA sp. nov.
(Fig. 1-2)

Mycelium plerumque superficiale, ex hyphis laevibus, ramosis, hyalinis, septatis, 1-2 um latis compositum. Conidiophora solitaria, erecta, recta, simplicia, septata, 100-150 um longa, 5-8 um crassa, parte fertili 4-5 um crassa, basi brunnea, apicem versus pallide brunneae. Cellulae conidiogenae terminale, cylindricae, hyalinae, proliferantes sympodialiter ad apicem 3-10 denticulos manifieste, cylindricis, indutae. Conidia acropleurogena, solitaria, fusiformia vel subcylindrica, 2-3 septata, 20-26 um longa (appendice exclusa), 4-5 um crassa, hyalina vel pallide brunneae, subhyalina, appendice simplice continua, usque ad 20 um longa, hyalina.
Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus

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[3] Researcher of the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires, Argentina.

LPS 44610.
Etymology: from Latin appendiculata: small appendage, referring to the extension of the conidia wall.

Mycelium mostly superficial composed of a network of smooth, branched, hyaline, septate, 1-2 um wide hyphae. Conidiophore solitary, erect, straight, simple, smooth walled, septate, 100-150 um high, 5-8 um wide at the base, 4-5 um wide at the apex, pale brown to brown, paler towards the apex. Conidiogenous cell terminal, cylindrical, hyaline, proliferating sympodially, with 3-10 cylindrical denticles at the apex, 1-2 um long, 1 um wide. Conidium acropleurogenous, solitary, fusiform to subcylindrical, 2-3 septate, hyaline to pale brown, subhyaline, 20-26 um long (excluding the appendage), 4-5 um thick, apical cell rostrate with a continuous appendage, formed by the extension of the outer wall, 20 um long, hyaline.

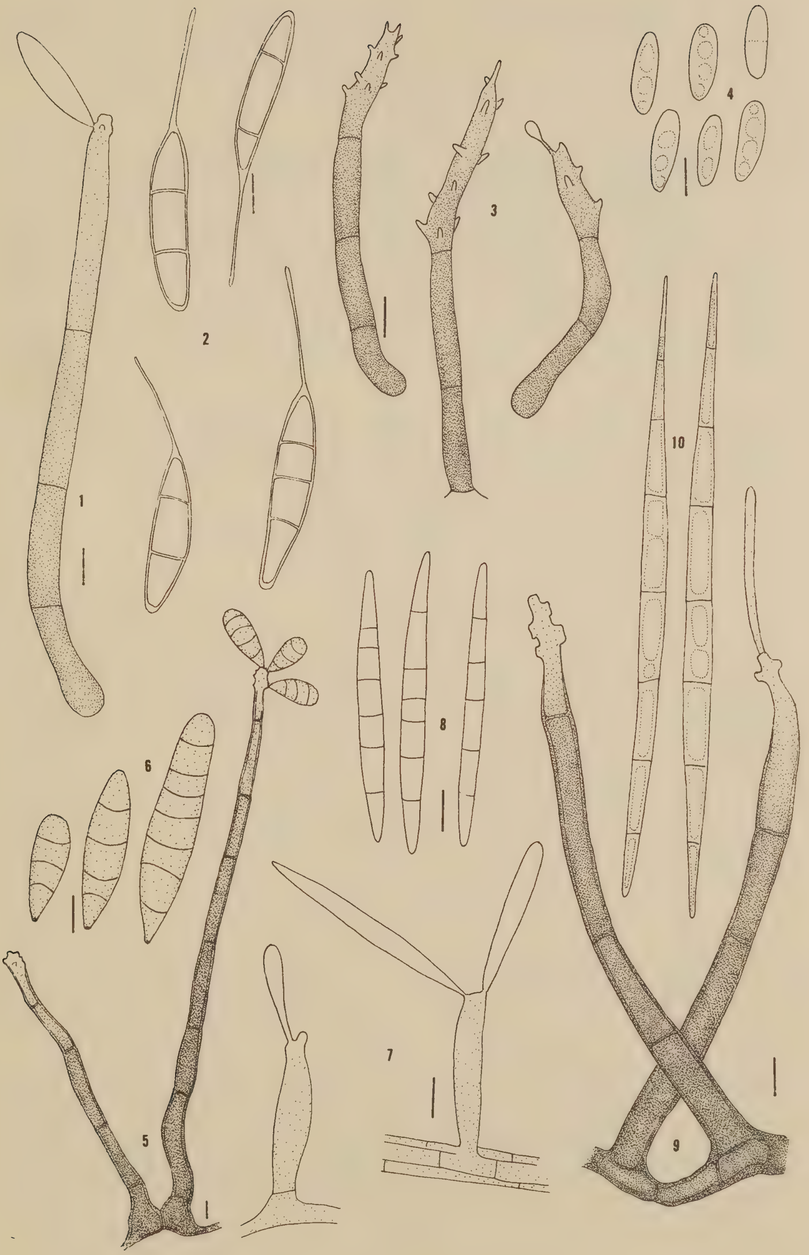
The closest species is D. argentina (Arambarri & Mengascini) Cabello & Cazau comb. nov. (Basionym: Subulispora argentina Arambarri & Mengascini apud Arambarri, Cabello & Mengascini, 1987); differing by the size and shape of the conidia.

DACTYLARIA LONGIDENTATA sp. nov.
(Fig. 3-4)

Mycelium ex hyphis ramosis septatis, hyalinis, modice fuscis, 2-4 um crassis compositum. Conidiophora solitaria, erecta, simplicia, 3-4 septata, 32-81 um longa, 2-3 um crassa, pallide brunneae. Cellulae conidiogenae terminale, cylindricae, pallide brunnea, proliferantes sympodialiter ad apicem, denticulata, dentes cylindrice 1-2.5 um longi, hyaline. Conidia acropleurogena, solitaria, ellipticae, 0-1 septata, 8-11 um longa, 2-3 um crassa, hyalina, guttulatis.
Ex cortice putrida, río Santiago, Buenos Aires, Argentina. Holotypus LPS 44611.
Etymology: from Latin longus: long and dentatus: toothed; referring to the conidium-bearing portion of the conidiogenous cells.

Mycelium mostly superficial composed of a network of smooth, branched, hyaline, septate, 2-4 um wide hyphae. Conidiophore solitary, erect, straight, simple, smooth walled, 3-4 septata, 32-81 um long, 2-3 um thick, pale brown becoming paler towards the apex. Conidiogenous cell terminal, cylindrical, subhyaline, proliferating sympodially, with cylindrical denticles, hyaline, 1-2.5 um long, 0.5 um wide. Conidia acropleurogenous, solitary, elliptical, 0-1 septate, 8-11 um long, 2-3 um thick, hyaline, guttulate.

DACTYLARIA APPENDICULATA. 1. Conidiophore. 2. Conidia.
DACTYLARIA LONGIDENTATA. 3. Conidiophores. 4. Conidia.
DACTYLARIA PARVISPORA. 5. Conidiophore and conidia. 6. Conidia.
MIRANDINA BREVIPHORA. 7. Conidiophore and conidia. 8. Conidia.
MIRANDINA CORTICOLA. 9. Conidiophore. 10. Conidia.
Bars indicate 5 um.



The closest species is *D. acerina* Matsushima (Matsushima, 1983) which differs by the shape of the conidia and the morphology of the conidiogenous cells.

DACTYLARIA PARVISPORA (PREUSS) DE HOOG & VON ARX
(Fig. 5-6)

de Hoog & von Arx, Kavaka 1: 58. 1973
=*Cordana parvispora* Preuss, Linneana 25: 728. 1852.
=*Pleurophragmium parvisporum* (Preuss) Holubová-Jechová, Ceská Mykol. 36: 223. 1972.

Colonies on ME attaining 15 mm diam in 10 days, smooth, brown. Conidiophores erect up to 125-300 um long, 4-6 um wide, gradually tapering towards the tip, dark brown, thick-walled, with up to 10 septa, with pimple-shaped hyaline denticles near the apex. Conidia pale brown, smooth walled, fusiform to obovoidal, 3-7 septate, 10-33 x 3-4 um.

Our species differs from the species described by de Hoog (1985) by the number of septa in the conidium. Morover the size of our conidium is larger than those described by de Hoog and show a dark scar.
Material examined LPS culture Nº 105.

MIRANDINA BREVIPHORA MATSUSHIMA
(Fig. 7-8)

Matsushima, Microfungi of the Solomon Islands, Papua--New Guinea: 37. 1971.

Mycelium aerial with hyphae subhyaline, 2-2.5 um wide. Conidiophore erect, straight, simple, 12-20 x 3-4 um near the base. Conidiogenous cell subhyaline, short cylindrical, 0-1 septate, with hyaline, short cylindrical denticles. Conidia hyaline smooth and thin walled with 5-6 septa, 35-60 x 2-3 um.

Our species differs from the original description in the smaller conidia, but we consider that all the other characters match well the original description.
Material examined: LPS culture Nº 129.

MIRANDINA CORTICOLA ARNAUD EX MATSUSHIMA
(Fig. 9-10)

Arnaud, Bull. trimest. Soc. mycol. Fr. 68: 206. 1952 (invalid; Art 36 ICBN)
Matsushima, Ic. Microf. a Matsushima lectorum: 96, 1975.

Mycelium inmersed. Conidiophore solitary, erect, cylindrical up to 4 septate, brown, thick-walled, 30-70 x 4-5 um, with scatered, short cylindrical denticles in the apical region. Conidia hyaline, thin-walled, fusiform, straight or lightly curved 80-100 x 3 um, 9-11 septate.
Material examined: ARGENTINA, Buenos Aires, río Santiago, leg. Cazau & Cabello, X-1989. LPS 44619.

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MYCOTAXON

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A RAPID, COMPUTER-BASED SYNOPTIC KEY TO GENERA OF GILLED FUNGI

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SUMMARY

Although synoptic keys are inherently superior to dichotomous keys, only the advent of personal computers has made their widespread adoption possible. A simple yet effective procedure is outlined for using askSam, a user-friendly database program, to do rapid multiple-feature searches for identification purposes. A key to the most widely recognized genera of North American gilled fungi is described.

Biosystematists have two concerns: to classify living organisms in a way that reflects their natural relationships, and to make it possible for other people to identify those organisms. I think it would be fair to say that most biosystematists spend most of their time thinking about, and working on, the first of those concerns. This is to be expected, because the goal of establishing the proper classification, of tying together bewilderingly different life forms in a logical and rational way, was the challenge that originally drew many of them to the discipline. Yet biosystematists also have an absolute responsibility to interface with their clients, the adherents of many other disciplines, and amateur naturalists. Ecologists, for example, are not just waiting for new classifications to emerge: they need to be able to identify the many organisms which are interacting in the ecosystems they are studying.

DICHOTOMOUS KEYS

So a significant fraction of a biosystematist's time must be invested in producing a means of identification. Illustrated catalogues are one kind of taxonomic output. Such compilations, when intelligently and accurately executed, are useful aids to identification. But when these compilations become large, and the taxa numerous, the user needs some kind of guide or short-cut which will provide rapid access to the appropriate illustrations and descriptions. This access is normally provided by means of a taxonomic key, which is basically an information storage and retrieval system. For many years, the only kind of key generally available was the dichotomous key, in which one answered a prescribed sequence of questions about the unknown organism at hand. The answers to these questions gradually excluded other taxa and sooner or later focussed on, and provided a name for, the unknown organism.

In theory, dichotomous keys should work well. In fact, beginners and even skilled observers head into such keys full of optimism, convinced that they have adequate observational data, only to run into a roadblock in the form of a question they cannot answer. It is very difficult to circumvent such barriers, because ignorance of that one answer either terminates the search, or necessitates subsequent guesswork, or even calls for exploration of two divergent lines of questioning, either of which can itself throw up another obstacle at any time. Failure to answer one question — any question — is therefore almost certain to cause failure and frustration. I am sure I do not need to provide examples:

everyone who has tried to use dichotomous keys, in the field or in the laboratory, has encountered such situations many times. There are many possible routes through any dichotomous key, but although such keys vary widely in their user-friendliness (which depends largely on the knowledge and skill of the compiler), every dichotomous key ever compiled suffers, by its very nature, from the frequently fatal flaw just described.

SYNOPTIC KEYS

In recent years, a second kind of key has become available. This is the synoptic key (a good example is the key to genera of Pezizales published by Korf [1972]). This kind of key is much more flexible than the dichotomous key, in that it allows the operator to enter the key at any point, using any feature of an organism, and to continue to work toward an identification by entering further characters in any order. This sounds ideal, but that flexibility comes at a price. When a choice is made, the key provides a list of numbers. These represent the taxa possessing that particular character or state. Each time a choice is made, a new list of numbers emerges. And each time, the lists must be compared and reconciled, by crossing off on the original list all numbers which do not appear in each new list. This gradually results in a shorter and shorter list of numbers which are common to all the choices made, and eventually, it is hoped, a single number, that of the unknown taxon. The amount of housekeeping involved in operating a synoptic key — the drudgery of comparing list after list of numbers — introduces a significant possibility of operator error, since the lists of numbers can be very long. Incorrect correlations lead inevitably to spurious or abortive identifications. It is apparent that if a synoptic key must be operated manually, the number of taxa that can be included in it is relatively small: it might be difficult to deal with more than fifty taxa. These operational problems kept synoptic keys in the background for many years, and gave the obsolete dichotomous key a stay of execution.

The advent of personal computers changed all this. Now the computer could be programmed to do all the housekeeping, very rapidly, and with complete accuracy. Biologists have been relatively slow to take advantage of this new freedom. A few user-friendly programs have been written which permit taxonomists to build and use synoptic keys. Examples of such programs are SYNKEY (available from Mycologue Publications, 331 Daleview Pl., Waterloo, Ontario, Canada N2L 5M5), from the Department of Biology, University of Waterloo, which runs on the now obsolescent Apple II+ computer; and PC-TAXON (available from COMPress, a division of Wadsworth, Inc., Wentworth, New Hampshire, U.S.A.), written by Fred Rhoades of the University of Western Washington, for MS-DOS computers. Both of these programs have been used effectively in producing synoptic keys to fairly large groups of organisms. SYNKEY, for example, has been used by students in a graduate course at the University of Waterloo to build a key to 105 species of the coprophilous ascomycete genus *Podospora*, using 15 characters, each divided up into a number of states. The characters included: number of spores per ascus, ascospore shape, ascospore length, shape of primary spore appendage, length of primary appendage relative to the spore, number and location of gelatinous (secondary) spore appendages, ratio of length of lower secondary appendage(s) to the primary appendage, perithecium ornamentation, and orientation of perithecium relative to the substrate.

PC-TAXON has been used to assemble keys to the genera of mushrooms, other macrofungi, mosses, and lichens of Whatcom County, Washington. I have used both of these programs over the past few years, and have found them and their products useful in teaching mycology, both in the laboratory and in the field. But all such programs have built-in disadvantages, in that they build keys in a slow and painstaking manner, accepting only one piece of information at a time in a repetitive, cyclical process. Both when building keys and using them, one can enter only one choice, then one has to go through a cycle of keystrokes before entering the next choice. This makes the assembly and use of keys rather laborious, and introduces an element of rigidity to the process, because for the key to work well, states must be provided for every taxon for all characters used.

MULTIPLE KEY-WORD SEARCHES IN A DATABASE

It occurred to me that it might be possible to speed up both database construction and identification processes by taking advantage of some of the built-in features of database programs, notably one called **askSam** (askSam Systems, P.O. Box 1428, Perry, FL 32347, U.S.A.) AskSam has a very fast algorithm, and is one of the more flexible databases, because data may be entered in a completely freeform manner, and records (each of which may contain up to 20 lines of text) can be subsequently retrieved by requesting any key-word or symbol in the record, or many possible combinations of key-words or symbols. AskSam is unusual among database programs in that although it can perform extremely complex functions, it can also be used by a completely untrained operator to store and retrieve data of many kinds. Illustrations can also be imported into askSam. This combination of features makes askSam ideal for use in teaching.

If all the taxonomically useful features of an organism or a taxon are entered in a single record, that record can subsequently be retrieved by entering on the query line any one word or any set of words, in any order, that are present in the record. Consider a database on agaric genera. If we have in hand an agaric with a white cap, the whole record containing its description can be retrieved by entering the descriptor word '**white**' on the query line. However, this search will also retrieve records for any other agaric which has something white about it: a white spore print, white gills, a white stipe or white spots on the cap. That would not be a very selective search, and you would retrieve many very different agarics.

But if the descriptor words entered in the database are prefixed by key letters unique to the particular structure in question, a far more selective search becomes possible. For example, if we enter in the database '**spwhite**' (for '**sp**ore print **white**'), when we subsequently type this word on the query line we retrieve only records concerning agarics with white spore prints, and automatically exclude any consideration of white caps, white gills or white stipes. Of course, if the agaric in question has a white cap, white gills and a white stipe, these facts can be entered in the record simply as '**cwhite**,' '**gwhite**' and '**stwhite**.' Now if we enter '**spwhite cwhite gwhite stwhite**' on the query line, askSam will simultaneously search for all of these words, and will retrieve only records that contain them all, highlighting these words in the displayed text. Anyone who knows anything about agarics will realize that a search based on those four key-words will retrieve several generic descriptions. But if we can add to the query line only one or two more key-words, such as '**vpresent**' (for **v**olva **present**), and '**rpresent**' (for **r**ing **present**), the search will yield only one generic description, that for *Amanita*. This description can then be checked against other characters of the specimen(s), including diagnostic microscopic features if necessary, and the identification confirmed.

Quantitative features must be dealt with differently. Size may be broken up into ranges expressed by single words, e.g. '**bsmall**' can represent basidiomata with caps 0.2-2.5 cm in diameter, and '**bmedium**' can represent those 2.5-10 cm in diameter. Alternatively, the entire known range in size can be listed in the database record, as follows: '**cdiam 3 4 5 6 7 8 9 10 cm**.' If the caps of two specimens in hand are measured, and found to be 6 cm and 8 cm in diameter, entering '**bmedium**' or '**cdiam 6 8 cm**' on the query line (depending on which of the two strategies above is chosen initially) would retrieve the description given above, and undoubtedly many others as well. It is unrealistic to expect to retrieve a single genus by inputting a single character. But it is surprising how few key-words one may need to enter in order to reduce the search to one or two genera.

AskSam has another excellent feature that facilitates sequential, increasingly selective searches. If the initial search produces more than one record, hitting the <Enter> key twice after the final record has been displayed will bring back the query line. That line can then be added to, deleted from, or changed in any other way, before <Enter> is pressed again to inaugurate the next search. It is almost impossible to convey how quickly sequential searches can be performed, enabling the operator to home in on a single genus, often in less than a minute. Response time does, of course, depend on the speed of the machine as well as that of the operator. An 80386-based computer performs multiple key-word searches almost instantaneously unless the database is large; but even 8088-based machines perform acceptably with askSam. Often, one need enter no more than four or five key-words on the query line to locate a genus. Scanning of the records retrieved, and comparison of the text with the specimen, will often reveal appropriate key-words that will rapidly narrow the search.

If the operator cannot make a single, unequivocal statement about a particular character, such as 'colour of spore print,' he or she can enter two or more colour descriptors, in the following form: '**sppink {OR} spbrown**.' Now askSam will do a Boolean search, retrieving records containing either of those key-words, but not necessarily both. Various other Boolean searches are possible, and may be useful as the skill of the operator grows. But most searches can be successfully prosecuted with simple sequences of key-words, which can appear on the query line in any order. If the operator is unsure whether the colour of the spore print is in the database as '**sppink**' or '**sppinkish**,' the entry on the query line can take the form '**sppink***.' The asterisk instructs the program to look for any descriptor beginning with '**sppink**,' even if that descriptor in its entirety is '**sppinkish**,' '**sppinkish-brown**' '**sppinkish lilac**' or any such combination. This kind of inclusive search can quickly determine what derivatives of the word 'pink' have been used in the descriptions.

The indented passage below is the record for the genus *Amanita*.

> "*Amanita* (Amanitaceae)
> Basidioma: bmedium, blarge, bvery large, cdiam 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 cm, bfleshy Spore print: spwhite
> Cap: cwarts, cpatches, cspots (white, cream, yellow), csmooth, cconvex, cplane, cwhite, cyellow, corange, cred, cscarlet, ctan, ctawny, cgrey, cbrown, cblackish brown, cgreenish yellow, cradially lined or furrowed, cseparable
> Gills: gfree, galmost free, gwhite
> Stipe: stfleshy, stseparable, stbase swollen, stwhite, stcream, styellow, stbrownish yellow, strooting, stscaly
> Ring: rpresent, rmembranous, rskirtlike, rabsent
> Volva: vpresent, vmembranous, vsheathlike, vrings on base of stipe
> Habitat: hsoil, hlitter, hwoods, hfields near trees
> Gill trama: gtdivergent
> Spores: ssmooth, samyloid, snonamyloid, sglobose, sellipsoid, sthinwalled, snogerm pore
> Comments: Over 100 species in North America; most mycorrhizal. Some species deadly poisonous, some edible, some hallucinogenic. Universal veil always present, but variable in form: sheath around base of stipe, scurfy rings near base, with or without warts or patches on cap."

Thus askSam, in addition to being a useful database program for many other purposes, can be easily adapted to produce rapid synoptic keys to any group of organisms. The full record displayed on the computer screen allows the operator to check important characters not examined earlier, and helps in the confirmation of identifications. The procedure described above can be used just as easily to produce identification-oriented databases for insects, mammals, birds, plants or any other organisms. In fact the same general approach could be made to the identification of members or subsets of any set of objects for which appropriate information is available.

Of course, the initial construction of the database will still be time-consuming, since all key-words have to be entered for every taxon being considered. But they do not need to be entered in any specific form, or in special fields, and since there is a real need for quick and easy identification of many different kinds of taxa, the investment of time will usually be well repaid. Records can be expanded or updated at any time.

Using the simple principles enunciated above, I have compiled a database on the 80 or so generally accepted genera of gilled fungi, using information drawn from a number of major sources (Kühner & Romagnesi 1953; Donk 1962; Miller 1972; Largent 1977; Largent et al. 1977; Moser 1978; Dähncke & Dähncke 1979; Smith & Weber 1980; Phillips 1981; Thiers 1982; Watling 1982; Arora 1986; Jenkins 1986; Singer 1986; Largent & Baroni 1989). Anyone could compile a very similar database, although it would take many hours. Those interested in acquiring this particular database on agarics should write to me directly. It can be supplied on a 5.25" or 3.5" floppy diskette, but recipients must be registered owners of askSam. In this context, askSam Systems offers askSam for class use at a very special educational discount.

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ERRATA, VOLUME THIRTY-EIGHT

Page	38	line	19	*for*	Claterosporium	*read*	Clasterosporium
			52	*for*	Claterosporium	*read*	Clasterosporium
	50		3	for	*elachistan*	read	*elachiston*
	54		29	for	*cribata*	read	*cribrata*
	84		27	*for*	spatulatus	*read*	spathulatus
				for	Polyporus spatulatus	*read*	Polyporus spathulatus
			33	*for*	spatulatus	*read*	spathulatus

MYCOTAXON

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CONTRIBUTION TO THE STUDY OF THE MYXOMYCETES IN SPAIN. III.
CATALOGUE OF MYXOMYCETES OF SPAIN

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ABSTRACT

According to the consulted literature 296 taxa of *Myxomycetes* (282 species and 14 varieties) have been cited in Spain including the Balearic and Canary Islands. For each taxon we indicate the province and a number which is reflected in the literature with the complete reference of the author and the work where it has been recorded. Wrong records have been corrected indicating the provenance of the corresponding taxonomic revision.

INTRODUCTION

The purpose of this contribution is to present to the international scientific community a preliminary essay of the catalogue of *Myxomycetes* of Spain. The first catalogue of *Myxomycetes* in Spain was made by TORRE & CALONGE (1975) and only 51 taxa were compiled in it. Since then numerous works have been done, contributing with data in our country.

To elaborate this catalogue we have adopted the following guidelines:

1.- We are only including the records when the author specifies the province or at least the region where the sample has been collected.

2.- In the case of the Canary and Balearic Islands we do not specify the island where the sample has been collected.

3.- The records considered by the other authors as doubtful, or not yet confirmed, are not included.

4.- We include the records of other authors, which are compiled in their papers, if the province where it has been collected is indicated. This makes that taxa collected one time appear with more than one reference, but we think it is important to contribute with the biggest amount of bibliographic information in the matter.

5.- We indicate the synonymous whith which the different taxa are cited in the spanish literature.

6.- Errors of determination of the catalogue are corrected indicating the author and paper where the correction has been done.

7.- We include records which have been presented in congress, symposia or national or international meetings during the year 1989. We assume that those before this date must have been published in different scientific journals. Nevertheless we have thought it would be interesting to include the contributions of GRACIA (1987a) and (1987b).

SEE ERRATA

We have made a map in which we indicate the number of taxa known in each province, considering the Balearic and Canary Islands in its entirety. We can deduce from all this that those provinces better known are Madrid (137), Barcelona (85), Murcia (77) and Segovia (71), which logically coincide with research centres where studies on these organisms have been made.

The Balearic (52) and Canary Islands (118) have a high number of records due to local specialists and the visit of national and foreign specialists.

However, there are a high number of provinces where no *Myxomycete* at all has been cited, this is the case of León, Logroño, Santander, Sevilla, Palencia and Zaragoza. This suggests us that we still have to make deeper studies in our country on this subject.

We are aware of the possible mistakes, principally due to omission which suppose this previous essay, but we are open to receive any kind of advice in order to improve this catalogue for the benefit of all the researchers on this subject.

CATALOGUE OF *MYXOMYCETES* OF SPAIN

Amaurochaete atra **(Alb. & Schwein.) Rostaf.**
AVILA: 55, 89
BARCELONA: 41
GERONA: 41
MADRID: 58
SEGOVIA: 59

Arcyria affinis **Rostaf. emend. Nann.-Brem.**
CACERES: 46, 55
MADRID: 58, 59
SEGOVIA: 28, 58

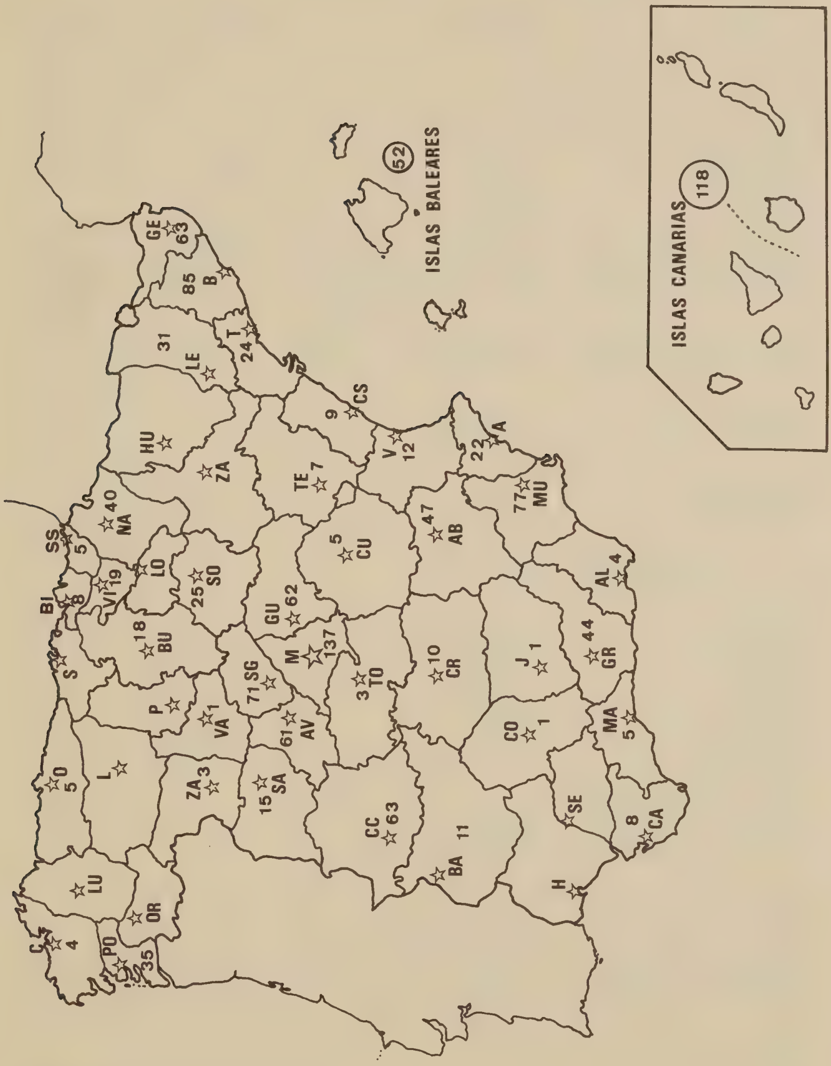
Arcyria annulifera **Torrend**
MURCIA: 41, 48, 54
TERUEL: 47

Arcyria carnea **(G. Lister) G. Lister**
= *Arcyria gulielmae* (G. Lister) G. Lister
BARCELONA: 41
MURCIA: 54
CANARIAS: 27

Arcyria cinerea **(Bull.) Pers.**
AVILA: 58, 59
BARCELONA: 39, 41, 83
CADIZ: 59
CACERES: 46, 55
GERONA: 39, 41
GUADALAJARA: 59
GRANADA: 36
MADRID: 2, 28, 55, 57, 58, 59, 62, 67
MURCIA: 41, 48, 54
NAVARRA: 31, 59, 66, 102
PONTEVEDRA: 113
SALAMANCA: 59
TARRAGONA: 41
VALENCIA: 41
BALEARES: 41, 92
CANARIAS: 27, 69, 106
GALICIA: 116
PAIS VASCO: 68, 104

Arcyria denudata **(L.) Wettst.**
= *Arcyria punicea* Pers.
ALAVA: 1
AVILA: 58, 59
BARCELONA: 41, 76, 83, 14
CACERES: 46, 55
CADIZ: 11, 79
GUADALAJARA: 59
LERIDA: 41, 75
MADRID: 16, 28, 57, 58, 59, 67, 107
MALAGA: 79
NAVARRA: 4, 31, 37, 66
PONTEVEDRA: 113
SALAMANCA: 59
SEGOVIA: 16, 28, 58, 107
TARRAGONA: 76
VIZCAYA: 82
CANARIAS: 27
GALICIA: 116

NUMBER OF *MYXOMYCETES* CITED IN SPAIN, IN PROVINCES AND ARCHIPELAGOS, ACCORDING TO THE CONSULTED LITERATURE


ISLAS BALEARES
52
ISLAS CANARIAS
118
GE 63
B 85
LE 31
T 24
CS 9
HU
ZA
TE 7
V 12
A 22
MU 77
NA 40
SS 5
VI 19
LO
SO 25
CU 5
AB 47
AL 4
BI 8
BU 18
GU 62
M 137
SG 71
TO 3
CR 10
J 1
GR 44
S
P
VA 1
AV 61
CO 1
MA 5
O 5
L
ZA 3
SA 15
CC 63
BA 11
SE
CA 8
LU
OR
H
C 4
PO 35

Abbreviations of the provinces.

A-Alicante, AB-Albacete, AL-Almería, AV-Avila, B-Barcelona, BA-Badajoz, BI-Vizcaya, BU-Burgos, C-Coruña, CA-Cádiz, CC-Cáceres, CO-Córdoba, CR-Ciudad Real, CS-Castellón, CU-Cuenca, GE-Gerona, GR-Granada, GU-Guadalajara, H-Huelva, HU-Huesca, J-Jaén, L-Lérida, LE-León, LO-Logroño, LU-Lugo, M-Madrid, MA-Málaga, MU-Murcia, NA-Navarra, O-Oviedo, OR-Orense, P-Palencia, PO-Pontevedra, S-Santander, SA-Salamanca, SE-Sevilla, SG-Segovia, SO-Soria, SS-Guipúzcoa, T-Tarragona, TE-Teruel, TO-Toledo, V-Valencia, VA-Valladolid, VI-Alava, Z-Zaragoza, ZA-Zamora.

PAIS VASCO: 68, 104

Arcyria ferruginea **Sauter**
ALAVA: 1
AVILA: 58, 59
BARCELONA: 39, 41
CACERES: 46, 55
GRANADA: 36
MADRID: 57, 58, 59, 62, 67, 107
VALLADOLID: 59
CANARIAS: 27
GALICIA: 115

Arcyria incarnata **(Pers.) Pers.**
ALAVA: 1
ALBACETE: 41, 49
AVILA: 58, 59
BARCELONA: 41
CACERES: 46, 55
CADIZ: 59
CIUDAD REAL: 107
CUENCA: 46, 55
GERONA: 41, 75, 83
GRANADA: 36, 71
GUADALAJARA: 55, 59, 87
MADRID: 28, 32, 46, 53, 55, 57, 58, 59, 67, 87
MURCIA: 41, 48, 54
NAVARRA: 31, 66
PONTEVEDRA: 113
SALAMANCA: 59
SEGOVIA: 28, 58, 59
TARRAGONA: 41
BALEARES: 41
CANARIAS: 27, 69
GALICIA: 115
PAIS VASCO: 68, 104

Arcyria insignis **Kalchbr. & Cooke**
BARCELONA: 12, 39
NAVARRA: 102
CANARIAS: 26

Arcyria leiocarpa **(Cooke) Martin & Alexop.**
GALICIA: 116

Arcyria major **(G. Lister) Ing**
BARCELONA: 41
GERONA: 41
GUADALAJARA: 59
BALEARES: 41

Arcyria obvelata **(Oeder) Onsberg**
= *Arcyria nutans* (Bull.) Grev.
= *Arcyria flava* Pers.
ALBACETE: 41
AVILA: 58, 59
BADAJOZ: 46, 55
BARCELONA: 39, 41, 75
CACERES: 46, 55
CIUDAD REAL: 59, 107
GERONA: 41, 81, 83
GRANADA: 36, 89, 90
GUADALAJARA: 59
LERIDA: 41, 79
MADRID: 46, 55, 57, 58, 59, 62, 67
MURCIA: 41, 48, 54, 70
NAVARRA: 59
PONTEVEDRA: 113
SEGOVIA: 55, 58, 59, 62, 87
TARRAGONA: 41
BALEARES: 41, 96
GALICIA: 115, 116
PAIS VASCO: 68, 104

Arcyria oerstedtii **Rostaf.**
MADRID: 57, 58, 67
MURCIA: 41, 48, 51, 54
NAVARRA: 31, 66
BALEARES: 41, 51
CANARIAS: 27

Arcyria pomiformis **(Leers) Rostaf.**
ALBACETE: 41, 48, 49
BARCELONA: 39, 41, 83
CACERES: 46, 55
CADIZ: 59
CIUDAD REAL: 55, 87, 107
GERONA: 41
GRANADA: 36, 71
GUADALAJARA: 59
MADRID: 58, 59
MURCIA: 41, 48, 54
NAVARRA: 31, 66
SALAMANCA: 59
SEGOVIA: 58, 59
CANARIAS: 27, 69
GALICIA: 116

Arcyria versicolor **Phill.**
MADRID: 57, 58, 59, 62, 67
GALICIA: 115

Badhamia affinis Rostaf.
GERONA: 39, 41
GUADALAJARA: 91, 94
MADRID: 57, 67
SEGOVIA: 94
SORIA: 91, 94
CANARIAS: 27

Badhamia capsulifera (Bull.) Berk.
CANARIAS: 27

Badhamia dearnessii Hagelst
CACERES: 46, 55
MURCIA: 73

Badhamia dubia Nann.-Brem.
PONTEVEDRA: 55, 87

Badhamia foliicola Lister
ALBACETE: 41
ALICANTE: 41
AVILA: 58, 65
BARCELONA: 41
CACERES: 46, 55
CASTELLON: 55, 87
GERONA: 39, 41
GRANADA: 36, 71, 90
GUADALAJARA: 65
LERIDA: 41
MADRID: 53, 55, 57, 58, 67, 84, 87, 101
MURCIA: 41, 48, 54
NAVARRA: 31, 66
PONTEVEDRA: 113
SEGOVIA: 58, 65
SORIA: 91, 94
BALEARES: 41
CANARIAS: 26, 69
GALICIA: 116

Badhamia gracilis (T. Macbride) T. Macbride
ALICANTE: 41
MURCIA: 41, 48, 54, 70
BALEARES: 40, 41
CANARIAS: 27, 46, 55, 69

Badhamia macrocarpa (Ces.) Rostaf.
GUADALAJARA: 91, 93
MADRID: 57, 58, 61, 67 (it corresponds to *Physarum ovisporum*, 88)
TARRAGONA: 41
GALICIA: 116

Badhamia nitens Berk.
CANARIAS: 26

Badhamia ovispora Racib.
GALICIA: 116

Badhamia panicea (Fr.) Rostaf.
ALICANTE: 41
AVILA: 58, 65
BARCELONA: 39, 41
GRANADA: 36, 90
GUADALAJARA: 94
MADRID: 53, 55, 57, 58, 67, 87
MURCIA: 41, 48, 54
SEGOVIA: 91, 94
TARRAGONA: 41
BALEARES: 40
CANARIAS: 27

Badhamia utricularis (Bull.) Berk.
ALBACETE: 73
ALMERIA: 73
BURGOS: 61
CACERES: 46, 55
MADRID: 2, 28, 55, 57, 58, 67, 84, 87, 101
MURCIA: 73
PONTEVEDRA: 113
SEGOVIA: 58, 61
ZAMORA: 61
CANARIAS: 27
GALICIA: 116
PAIS VASCO: 68

Badhamia versicolor Lister
MADRID: 55, 58, 59, 87
MURCIA: 73

Badhamiopsis ainoae (Yamashiro) Brooks & Keller
SEGOVIA: 91
SORIA: 91
CANARIAS: 106

Calomyxa metallica (Berk.) Nieuwl.
BARCELONA: 41, 42
CACERES: 42
SORIA: 91
CANARIAS: 27, 69

Calonema luteolum Kow.
ASTURIAS: 30

Ceratiomyxa fruticulosa (Müll.) T. Macbride
ALBACETE: 49
BARCELONA: 83
CACERES: 46, 55
CADIZ: 63
CIUDAD REAL: 107
GERONA: 39
LERIDA: 12, 39
MADRID: 57, 62, 63, 67, 107
MALAGA: 79
NAVARRA: 66
SEGOVIA: 28, 62, 63
TARRAGONA: 39
VIZCAYA: 82
CANARIAS: 3, 7, 27
GALICIA: 116
PAIS VASCO: 68, 104

Ceratiomyxa porioides (Alb. & Schwein.) Schroet.
= *Ceratiomyxa fruticulosa* var. *porioides* (Alb. & Schwein.) Lister
BARCELONA: 83, 99

Ceratiomyxa sphaerosperma Boedijn
NAVARRA: 37, 102

Cienkowskia reticulata (Alb.& Schw.) Rostaf.
CANARIAS: 27

Clastoderma debaryanum Blytt.
ALAVA: 42

Clastoderma pachypus Nann.-Brem.
MADRID: 58, 59

Collaria arcyrionema (Rostaf.) Nann.-Brem.
= *Lamproderma arcyrionema* Rostaf.
ALICANTE: 41
MADRID: 28, 57, 58, 67
BALEARES: 40, 41
CANARIAS: 27
GALICIA: 116
PAIS VASCO: 68

Collaria elegans (Racib.) Dhillon & Nann.-Brem.
GERONA: 41
MADRID: 58, 60
MURCIA: 54

Collaria lurida (Lister) Nann.-Brem.
ALICANTE: 41
GRANADA: 36
NAVARRA: 31, 66

Collaria rubens (Lister) Nann.-Brem.
ALICANTE: 41
AVILA: 58, 60
CACERES: 46, 55
MADRID: 58, 60
SEGOVIA: 58, 60
TARRAGONA: 41

Colloderma macrotubulatum Nann.-Brem. & Lado
MADRID: 58, 88

Colloderma oculatum (Lippert.) G. Lister
NAVARRA: 31, 66
SEGOVIA: 28, 58
CANARIAS: 26

Comatricha alta Preusz.
BARCELONA: 41, 51
CUENCA: 59
GRANADA: 36
MADRID: 51, 53, 59
MURCIA: 41, 54
VALENCIA: 51

Comatricha dictyospora Celak
MADRID: 57 and 62 and 67 (they correspond to *Stemonitopsis hyperopta* and *Stemonitopsis amoena*, 58)
GALICIA: 116

Comatricha elegans **(Racib.) G. Lister**
GERONA: 39
GUADALAJARA: 91, 94
PONTEVEDRA: 113
SEGOVIA: 91, 94
SORIA: 91, 94
CANARIAS: 27, 69
GALICIA: 116

Comatricha ellae **Harkönen**
GUADALAJARA: 91, 93
MADRID: 58, 88
SEGOVIA: 58, 91, 93
SORIA: 91, 93
CANARIAS: 27

Comatricha laxa Rostaf.
BARCELONA: 83
GUADALAJARA: 88
MADRID: 58
MURCIA: 41, 54
SEGOVIA: 58, 88, 91
SORIA: 91, 94
CANARIAS: 27, 69

Comatricha lurida Lister
GRANADA: 89
GUADALAJARA: 91, 94
MURCIA: 48
SALAMANCA: 64

Comatricha nigra **(Pers.) Schröet.**
= *Comatricha friesiana* (de Bary) Rostaf.
= *Stemonitis ovata* Pers.
ALAVA: 1
ALBACETE: 41, 49, 70
ALICANTE: 41
AVILA: 58, 59
BARCELONA: 12, 39, 41, 83
BURGOS: 59
CACERES: 55
CUENCA: 46, 55, 59
GERONA: 39, 41, 83
GRANADA: 36, 71, 90
GUADALAJARA: 59
LERIDA: 41
MADRID: 28, 32, 46, 53, 55, 57, 58, 59, 62, 67, 107
MÁLAGA: 38, 110
MURCIA: 41, 48, 54
NAVARRA: 31, 37, 66, 102
PONTEVEDRA: 113
SEGOVIA: 58, 59
TARRAGONA: 41
TOLEDO: 59
ZAMORA: 59
BALEARES: 41
CANARIAS: 27, 69
GALICIA: 116
PAIS VASCO: 68, 104

Comatricha pulchella **(C. Bab.) Rostaf.**
CIUDAD REAL: 107, 119
MADRID: 57, 67 (it corresponds to *Stemonitopsis typhina*, 58)
GERONA: 41
MURCIA: 41, 54
CANARIAS:69

Comatricha rigidiretta **Nann.-Brem.**
CANARIAS: 27

Comatricha subcaespitosa **Peck**
CANARIAS: 27

Comatricha suksdorfii **Ellis & Ev.**
LERIDA: 43

Comatricha tenerrima (M.A. Curtis) G. Lister
ALBACETE: 73

Craterium aureum (Schum.) Rostaf.
BARCELONA: 41
CACERES: 46, 55
BALEARES: 78

Craterium leucocephalum (Pers.) Ditmar var. *leucocephalum*
ALBACETE: 41, 49
AVILA: 58, 65
BARCELONA: 41, 77, 83
CACERES: 46, 55, 65
GRANADA: 36, 71, 90
GUADALAJARA: 64
MADRID: 15, 53, 58
MURCIA: 41, 48, 54
SEGOVIA: 64
TARRAGONA: 39, 41
BALEARES: 55, 87

Craterium leucocephalum var. *scyphoides* (Cooke & Balf.) G. Lister
CACERES: 46, 55
GUADALAJARA: 61
MADRID: 58, 61

Craterium minutum (Leers) Fr.
AVILA: 58, 65
BARCELONA: 41
CACERES: 46, 55
GRANADA: 36, 89, 90
MADRID: 58, 65
MURCIA: 41, 48, 54
PONTEVEDRA: 113
BALEARES: 41, 78
GALICIA: 116
PAIS VASCO: 68

Craterium rubronudum Lister
CANARIAS: 26

Cribraria argillacea (Pers.) Pers.
BARCELONA: 25, 83
CACERES: 46, 55
GERONA: 39, 41
MADRID: 57, 58, 67, 84
NAVARRA: 31, 37, 105
PONTEVEDRA: 113
CANARIAS: 27
GALICIA: 116
PAIS VASCO: 68

Cribraria aurantiaca Schrader
= *Cribraria vulgaris* var. *aurantiaca* (Schrad.) Pers.
BARCELONA: 25, 41
GERONA: 39
CANARIAS: 26

Cribraria cancellata (Batsch) Nann.-Brem. var. *cancellata*
= *Dictydium cancellatum* (Batsch) T. Macbride
ALBACETE: 41, 49
AVILA: 60
BARCELONA: 39, 41, 83
CACERES: 46, 55
CIUDAD REAL: 107
GERONA: 39, 41, 83
GUADALAJARA: 62
LERIDA: 39, 41
MADRID: 57, 58, 60,62
MURCIA: 41, 48, 54
PONTEVEDRA: 113
SEGOVIA: 62
CANARIAS: 26
GALICIA: 116

Cribraria cancellata var. *fusca* (Lister) Nann.-Brem.
AVILA: 58, 60
BARCELONA: 83
GERONA: 83
MADRID: 58, 60
PONTEVEDRA: 113
SEGOVIA: 58

Cribraria candida Rab.
ARAGóN: 38, 110

Cribraria macrocarpa Schrader
NAVARRA: 37

Cribraria microcarpa (Schrader) Pers.
PONTEVEDRA: 113
GALICIA: 116

Cribraria minutissima Schwein.
BARCELONA: 41

Cribraria mirabilis (Rostaf.) Massee
= *Dictydium mirabile* (Rostaf.) Meyl.
MADRID: 57, 58, 67 **SEGOVIA:** 58, 60

Cribraria persoonii Nann.-Brem.
MADRID: 58, 88 **SEGOVIA:** 58

Cribraria piriformis Schrader
AVILA: 58, 88

Cribraria rufa (Roth.) Rostaf.
AVILA: 58, 60 **MADRID:** 57, 58, 67 **PAIS VASCO:** 68

Cribraria splendens (Schrader) Pers.
GERONA: 41

Cribraria tenella Schrader
NAVARRA: 31, 105

Cribraria violacea Rex
BARCELONA: 39, 41, 83 **GUADALAJARA:** 60 **MURCIA:** 73
CANARIAS: 27

Cribraria vulgaris Schrader var. *vulgaris*
= *Cribraria aurantiaca* Schrad.
AVILA: 58, 60 **MADRID:** 58, 60 **MURCIA:** 41, 54
PONTEVEDRA: 55, 87, 113 **SEGOVIA:** 58, 60 **GALICIA:** 116

Cribraria vulgaris var. *oregana* (H.C. Gilbert) Nann.-Brem. & Lado
AVILA: 58 **MADRID:** 58 **SEGOVIA:** 58, 88

Diachea leucopodia (Bull.) Rostaf.
≡ *Stemonitis leucopodia* D.C.
BARCELONA: 41, 83 **GERONA:** 39, 41 **GUIPUZCOA:** 68
ARAGÓN: 38, 110 **PAÍS VASCO:** 104

Diachea radiata G. Lister & Petch
GALICIA: 116

Diachea subsessilis Peck
GALICIA: 116 (cited as *Diderma subsesylis* ?)

Diacheopsis nannengae Moreno, Illana & Heykoop
MADRID: 55, 87

Dianema corticatum Lister
TARRAGONA: 39, 41

Dianema harveyi Rex
GUADALAJARA: 91, 93 **JAEN:** 42 **MADRID:** 58, 61
SORIA: 91, 93 **TOLEDO:** 61

Dictydiaethalium ferrugineum **Nann.-Brem.**
MADRID: 58, 88

Dictydiaethalium plumbeum **(Schum.) Rostaf.**
ALBACETE: 41, 49
BARCELONA: 39, 41, 83
CASTELLON: 41
GERONA: 39, 41, 83
MURCIA: 41, 48, 54
TARRAGONA: 41
CANARIAS: 27
GALICIA: 116
PAÍS VASCO: 68

Dictydium rutilum G. Lister
GALICIA: 116

Diderma alpinum **Meyl.**
BARCELONA: 45

Diderma asteroides **(Lister & G. Lister) G. Lister**
AVILA: 58, 65
MADRID: 58, 101
MURCIA: 41, 48, 54
BALEARES: 40, 41

Diderma cinereum **Morgan**
ALBACETE: 73
GUADALAJARA: 88

Diderma chondrioderma **(de Bary & Rostaf.) Lister**
MADRID: 55, 87
CANARIAS: 26

Diderma darjeelingense **Thind & Sehgal**
GERONA: 41

Diderma floriforme **(Bull.) Pers.**
SEGOVIA: 58
PAIS VASCO: 68

Diderma fragilis **Arambarri**
MADRID: 46

Diderma globosum **Pers.**
= *Chondrioderma globosum* (Pers.) Rostaf.
ALBACETE: 73
OVIEDO: 111

Diderma hemisphaericum **(Bull). Hornem.**
AVILA: 58, 59
BARCELONA: 39, 41, 83
GUADALAJARA: 91, 94
MADRID: 58, 59
CANARIAS: 27

Diderma lyalii **(Massee) T. Macbride**
BARCELONA: 45

Diderma montanum **(Meyl.) Meyl.**
PAIS VASCO: 104

Diderma niveum **(Rostaf.) T. Macbride**
BARCELONA: 41
GRANADA: 36, 89, 90
MADRID: 57, 64 (it corresponds to *Diderma umbilicatum*, 58), 67

Diderma platycarpum **Nann.-Brem.**
CACERES: 46, 55

Diderma radiatum (L.) Morgan
GRANADA: 36, 71
MADRID: 57, 64, 67

Diderma rufoestriatum Nann.-Brem. & Lado
AVILA: 58, 88

Diderma spumarioides (Fr.) Fr.
ALBACETE: 41, 49
ALICANTE: 41, 58
AVILA: 58, 59
CASTELLON: 41
GRANADA: 58 (as *Physarum bitectum*, 89)
MADRID: 55, 58, 59, 87
MURCIA: 41, 48, 54
SALAMANCA: 58 (as *Diderma testaceum*, 64)
BALEARES: 55, 78, 87
PAIS VASCO: 68

Diderma testaceum (Schrad.) Pers.
SALAMANCA: 64 (it corresponds to *Diderma spumaroides*, 58)

Diderma trevelyani (Grev.) Fr. var. trevelyani
AVILA: 58, 64, 65
CACERES: 46, 55
GRANADA: 36, 90
MADRID: 57, 58, 67
SEGOVIA: 58, 65

Diderma trevelyani var. *nivale* Meyl.
LERIDA: 43

Diderma umbilicatum Pers.
ALBACETE: 41, 49
AVILA: 58
GERONA: 41
GRANADA: 36
MADRID: 58 (as *Diderma niveum*, 64)

Didymium anellus Morgan
MADRID: 53, 58, 59
MURCIA: 41, 48
SEGOVIA: 58, 59
CANARIAS: 26, 30

Didymium bahiense Gottsberger
ALBACETE: 41
AVILA: 58, 60
CACERES: 46, 55
CORUÑA: 46, 55
GERONA: 41
GRANADA: 36
MADRID: 46, 53, 55, 87
MURCIA: 41, 54
SEGOVIA: 46, 55, 87

Didymium clavus (Alb. & Schwein.) Rabenh.
CACERES: 46, 55
GRANADA: 36, 71
MADRID: 58, 60
MURCIA: 73
SEGOVIA: 55
VALENCIA: 41
CANARIAS: 27, 69

Didymium comatum (Lister) Nann.-Brem.
ALICANTE: 41

Didymium crustaceum Fr.
MADRID: 15, 58

Didymium difforme (Pers.) Gray
ALBACETE: 41, 49
ALICANTE: 41
AVILA: 58, 65
BARCELONA: 41
CACERES: 46, 55
GERONA: 41
GRANADA: 36
LERIDA: 41
MADRID: 46, 53, 55, 58, 65, 87
SEGOVIA: 58, 65, 91
SORIA: 91, 94
VALENCIA: 41

BALEARES: 40, 41
CANARIAS: 26

Didymium dubium Rostaf.
ALBACETE: 41, 49
ALICANTE: 41
MADRID: 58, 61
MURCIA: 54
PONTEVEDRA: 113
TARRAGONA: 39, 41
CANARIAS: 26, 30
GALICIA: 116

Didymium eximium Peck
AVILA: 58, 61
CACERES: 46, 55
CÓRDOBA: 46, 55
VALENCIA: 41

Didymium iridis (Ditmar) Fr.
GALICIA: 116

Didymium karstensii Nann.-Brem.
MADRID: 55, 87

Didymium laxifila G. Lister & Ross.
GRANADA: 36, 71, 90
MADRID: 58, 59
MURCIA: 41, 48, 54
BALEARES: 41

Didymium marineri Moreno, Heykoop & Illana
CASTELLON: 55, 87

Didymium megalosporum Berk. & Curt.
CANARIAS: 26

Didymium melanospermum (Pers.) T. Macbride var. *melanospermum*
= *Didymium farinaceum* Schrad.
AVILA: 58, 65
CACERES: 46, 55
GRANADA: 36, 71
MADRID: 46, 55, 57, 58, 65, 67, 87
MURCIA: 41, 48, 54
CANARIAS: 6, 27
PAIS VASCO: 68

Didymium melanospermum var. *bicolor* G. Lister
MADRID: 58

Didymium minus (Lister) Morgan
ALBACETE: 73
AVILA: 58, 65
BARCELONA: 41, 83
BURGOS: 55, 87
CACERES: 46, 55
MADRID: 32, 33, 58
MURCIA: 73

Didymium muscorum Lakhanpal & Mukerji
AVILA: 58
CACERES: 46, 55
MADRID: 58, 85
SEGOVIA: 58
PAIS VASCO: 68

Didymium nigripes (Link) Fr.
BARCELONA: 41, 52, 83
CACERES: 46, 55
GERONA: 41, 83
GRANADA: 36, 89
NAVARRA: 31, 66
PONTEVEDRA: 113
VIZCAYA: 68
CANARIAS: 27
GALICIA: 116
PAIS VASCO: 68

Didymium ovoideum Nann.-Brem.
ALBACETE: 73
MURCIA: 73
TARRAGONA: 41

Didymium quitense (Pat.) Torrend
GUADALAJARA: 61
MADRID: 107
MURCIA: 48
CANARIAS: 86

Didymium serpula Fr.
BARCELONA: 83

Didymium squamulosum (Alb. & Schwein.) Fr.
ALBACETE: 41, 49
ALICANTE: 41
AVILA: 58, 65
BARCELONA: 39, 41, 83
CACERES: 46, 55
CASTELLON: 41
GERONA: 41
GRANADA: 36, 71, 89, 90
GUADALAJARA: 65
HUELVA: 21
LERIDA: 41
MADRID: 53, 55, 57, 58, 67, 87
MURCIA: 41, 48, 54
PONTEVEDRA: 113
SEGOVIA: 58, 65
TARRAGONA: 41
VALENCIA: 41
BALEARES: 40, 41
CANARIAS: 6, 27, 69, 109
GALICIA: 116

Didymium sturgisii Hagelstein
GUADALAJARA: 88, 91, 93
SEGOVIA: 91, 93
SORIA: 91, 93

Didymium trachysporum G. Lister
ALMERIA: 5, 62
GRANADA: 36
GUADALAJARA: 91, 93
TERUEL: 46, 55
BALEARES: 30
CANARIAS: 27

Didymium tubulatum Jahn.
AVILA: 58
GERONA: 41
MADRID: 58

Didymium vaccinum (Dur. & Mont.) Buchet
MADRID: 55, 87
MURCIA: 41, 48, 54
CANARIAS: 27, 69

Didymium verrucosporum Welden
MADRID: 58, 60
CANARIAS: 27
GALICIA: 116

Echinostelium apitectum Whitney
GUADALAJARA: 91
BALEARES: 92

Echinostelium arboreum Keller & Brooks
BALEARES: 92

Echinostelium brooksii Whitney
BARCELONA: 83
GERONA: 83

Echinostelium coelocephalum Brooks & Keller
BALEARES: 92

Echinostelium colliculosum Whitney & Keller
BARCELONA: 83
BURGOS: 91
GERONA: 83
GUADALAJARA: 91
SORIA: 91
TERUEL: 91
BALEARES: 92
CATALUÑA: 83

Echinostelium corynophorum Whitney
SORIA: 91

SEE ERRATA

Echinostelium cribrarioides Alexop.
CANARIAS: 26

Echinostelium elachistan Alexop.
CANARIAS: 26, 27

Echinostelium fragile **Nann.-Brem.**
BARCELONA: 83
GUADALAJARA: 94
MADRID: 94
NAVARRA: 31, 66

Echinostelium minutum de Bary
BARCELONA: 83
GERONA: 83
GUADALAJARA: 94
MURCIA: 54
NAVARRA: 31, 66
SEGOVIA: 58, 59
TARRAGONA: 39, 41
BALEARES: 92
CANARIAS: 27

Enerthenema melanospermum T. **Macbride & Martin**
LERIDA: 39, 41

Enerthenema papillatum (Pers.) **Rostaf.**
AVILA: 58, 65
BADAJOZ: 46, 55
BARCELONA: 83
BURGOS: 84
GERONA: 39, 83
LERIDA: 39, 41
MADRID: 32, 33, 57, 58, 64, 67, 107
MURCIA: 41, 54
PONTEVEDRA: 113
SEGOVIA: 58, 65
CANARIAS: 27, 69
GALICIA: 116

Enteridium intermedium **(Nann.-Brem.) Farr**
CANARIAS: 69
GALICIA: 116

Enteridium liceoides (Lister) G. Lister
MADRID: 58 and 88 (they correspond to *Enteridium olivaceum*, 93)

Enteridium lycoperdon (Bull.) **Farr**
= *Reticularia lycoperdon* Bull.
ALAVA: 82
BARCELONA: 76, 81
BURGOS: 59
CACERES: 46, 55
GERONA: 39, 41, 52
GRANADA: 36, 55, 87, 89, 90
HUELVA: 21
HUESCA: 79
MADRID: 2, 24, 53,57, 58, 59, 67, 84, 107
MURCIA: 54
OVIEDO: 72
SALAMANCA: 59
VIZCAYA: 68
CANARIAS: 27
GALICIA: 116
PAIS VASCO: 68

Enteridium olivaceum **Ehrenb.**
= *Reticularia olivacea* (Ehrenb.) Fr.
BURGOS: 91, 93
GUADALAJARA: 91, 93
MADRID: 57, 58 (part of it as *Enteridium liceoides*, 93), 64, 67, 88 (as *Enteridium liceoides*, 93).
NAVARRA: 31, 105 (it corresponds to *Fuligo septica*, 93)
SORIA: 91, 93

Enteridium splendens **var.** ***juranum*** **(Meyl.) Härkönen**
= *Reticularia jurana* Meyl.
LERIDA: 39, 41
PONTEVEDRA: 113

***Fuligo cinerea* (Schwein.) Morgan**
CUENCA: 46, 55 **GRANADA:** 36, 71 **MADRID:** 2, 85
VIZCAYA: 82 (it corresponds to *Mucilago crustacea*, obs. pers.)
BALEARES: 114 **CANARIAS:** 30 **GALICIA:** 115

Fuligo septica* (L.) Wigg. var. *septica
= *Fuligo varians* Sommerf.
ALAVA: 1 **ALMERIA:** 22 **AVILA:** 18, 55, 87, 65
BARCELONA: 39, 41, 75, 77, 81 **CACERES:** 46, 55
CASTELLON: 84 **CUENCA:** 46, 55 **GERONA:** 39, 41, 83
GRANADA: 36, 89 **GUADALAJARA:** 65 **LERIDA:** 41
MADRID: 2, 23, 28, 55, 57, 58, 67, 84, 87, 107 **MALAGA:** 79
MURCIA: 41, 48, 54 **NAVARRA:** 4, 31, 37, 105 (as *E. olivaceum*, 93)
SALAMANCA: 65 **SEGOVIA:** 55, 58, 65, 87 **VALENCIA:** 77
VIZCAYA: 82 **BALEARES:** 114 **CANARIAS:** 27
GALICIA: 115 **PAIS VASCO:** 68, 104

***Fuligo septica* var. *candida* (Pers.) R.E. Fr.**
MADRID: 10, 58 **SEGOVIA:** 58

***Fuligo septica* var. *flava* Pers.**
AVILA: 58 **MADRID:** 58, 61 **OVIEDO:** 72
CATALUÑA: 100

***Fuligo septica* var. *violacea* (Pers.) Lister**
OVIEDO: 72

***Hemitrichia abietina* (Wigand) G. Lister**
AVILA: 58, 65 **GERONA:** 41 **MADRID:** 28, 57, 58, 67
SEGOVIA: 28, 58, 65

***Hemitrichia calyculata* (Speg.) Farr**
PONTEVEDRA: 113 **PAIS VASCO:** 68

***Hemitrichia clavata* (Pers.) Rostaf.**
= *Trichia clavata* Pers.
BARCELONA: 25, 41 **GERONA:** 25, 41 **GUADALAJARA:** 62
GUIPUZCOA: 68 **LERIDA:** 41 **CANARIAS:** 6, 17, 27
PAIS VASCO: 68, 104

***Hemitrichia leiotricha* (Lister) G. Lister**
MADRID: 57, 64, 67 **SALAMANCA:** 64

***Hemitrichia serpula* (Scop.) Rostaf.**
BARCELONA: 25 **GERONA:** 41 **PAIS VASCO:** 68, 104

***Lamproderma sauteri* Rostaf.**
LERIDA: 43

***Lamproderma scintillans* (Berk. & Br.) Morgan**
ALBACETE: 73 **BARCELONA:** 83 **GERONA:** 41
GRANADA: 36 **MADRID:** 58, 59 **PONTEVEDRA:** 113
SEGOVIA: 58, 59 **GALICIA:** 116

Leocarpus fragilis (Dickson) Rostaf.
= *Leocarpus vernicosus* (Pers.) Link
ALAVA: 1   **AVILA**: 18, 58   **BADAJOZ**: 46, 55
BARCELONA: 39, 41   **BURGOS**: 82   **CACERES**: 46, 55, 84
GERONA: 39, 41   **GRANADA**: 36, 89, 90   **GUADALAJARA**: 46, 55, 65
LERIDA: 52   **MADRID**: 2, 46, 55, 57, 58, 67, 84
MURCIA: 41, 48, 54   **NAVARRA**: 31, 37, 105   **SALAMANCA**: 97
SEGOVIA: 58, 65   **BALEARES**: 41, 55, 78, 87   **CANARIAS**: 3, 6, 27, 69
PAIS VASCO: 68, 104

Lepidoderma chailletii Rostaf.
NAVARRA: 31, 66   **GALICIA**: 116

Leptoderma iridescens G. Lister
ALBACETE: 41, 50   **MADRID**: 50, 58

Licea belmontiana Nann.-Brem.
CANARIAS: 27

Licea biforis Morgan
CANARIAS: 27

Licea castanea G. Lister
GUADALAJARA: 91, 93   **MURCIA**: 41, 48, 54   **SEGOVIA**: 91, 93
SORIA: 91, 93   **TERUEL**: 91, 93   **CANARIAS**: 27

Licea denudescens Keller & Brooks
CADIZ: 56

Licea kleistobolus G. W. Martin
ALICANTE: 41   **BARCELONA**: 83   **MADRID**: 58, 94
MURCIA: 54   **NAVARRA**: 31, 66   **PONTEVEDRA**: 113
BALEARES: 40, 41, 92   **CANARIAS**: 27   **GALICIA**: 116

Licea iridis B. Ing sp. inéd.
BARCELONA: 83

Licea marginata Nann.-Brem.
CANARIAS: 27

Licea minima Fr.
ALBACETE: 41, 49   **AVILA**: 58, 59   **BARCELONA**: 83
GERONA: 39, 41   **GUADALAJARA**: 59   **LERIDA**: 41
MADRID: 57, 58, 59, 67   **MURCIA**: 41, 48, 54   **OVIEDO**: 55, 87
PONTEVEDRA: 113   **SEGOVIA**: 58, 59   **BALEARES**: 41
GALICIA: 116

Licea nannengae Pando & Lado
BURGOS: 95   **GUADALAJARA**: 95   **SEGOVIA**: 95
SORIA: 95

Licea parasitica (Zukal) G. W. Martin
BARCELONA: 83   **BURGOS**: 91, 94   **GUADALAJARA**: 91, 94
MADRID: 58, 59   **SEGOVIA**: 58, 59, 91, 94   **SORIA**: 91, 94

TERUEL: 91, 94
CANARIAS: 27

Licea pedicellata (Gilbert) Gilbert
CANARIAS: 26

Licea perexigua Brooks & Keller
BALEARES: 92

Licea pusilla Schrader
MADRID: 58
CANARIAS: 27

Licea testudinacea Nann.-Brem.
ALBACETE: 73

Licea variabilis Schrader
BARCELONA: 39, 41
CACERES: 46, 55
GERONA: 41

Lindbladia tubulina Fr.
AVILA: 58, 61
BARCELONA: 39, 41
GERONA: 41
LERIDA: 41
MADRID: 58, 61
SEGOVIA: 58, 61
BALEARES: 40

Lycogala epidendrum (L.) Fr.
= *Lycogala miniatum* Pers.
ALAVA: 1
ALBACETE: 41, 48, 49
ALICANTE: 41
ALMERIA: 22
AVILA: 18, 55, 58, 65, 87
BADAJOZ: 46, 55
BARCELONA: 39, 41, 76, 81, 83
CACERES: 46, 55, 97
CADIZ: 65
CIUDAD REAL: 107
CORUÑA: 8
GERONA:39, 41, 52, 75, 83
GRANADA: 36, 89, 90
LERIDA: 39, 41, 98
MADRID: 2, 16, 19, 23, 28, 32, 53, 55, 57, 58, 67, 84, 87, 107
MALAGA: 79
MURCIA: 41, 48, 54
NAVARRA: 29, 31, 37, 66, 112
PONTEVEDRA: 113
SALAMANCA: 97
SEGOVIA: 16, 28, 58
TARRAGONA: 41, 76
VALENCIA: 34
VIZCAYA: 82
BALEARES: 40, 41, 78, 96
CANARIAS: 3, 6, 7, 27, 103
GALICIA: 115
PAIS VASCO: 68, 104

Lycogala exiguum Morgan
MADRID: 57, 62, 67
GALICIA: 115
PAIS VASCO: 68

Lycogala flavofuscum (Ehrenb.) Rostaf.
CACERES: 46, 55
MADRID: 53, 55, 57, 58, 62, 65, 67, 87
PAIS VASCO: 104

Macbrideola cornea (G. Lister & Cran) Alexop.
BARCELONA:83
BURGOS: 91, 93
GUADALAJARA:59, 91,93
MADRID: 58, 59
SEGOVIA: 58, 91, 93
SORIA: 91, 93
TERUEL: 91, 93
BALEARES: 40, 41, 92
CANARIAS: 27

Macbrideola decapillata H.C. Gilbert
BURGOS: 91
GUADALAJARA: 91
SORIA: 91
TERUEL: 91

SEE ERRATA

***Macbrideola macrospora* (Mann-Brem.) Ing**
BARCELONA: 83

***Macbrideola oblonga* Pando & Lado**
SORIA: 95

***Macbrideola scintillans* H.C. Gilbert**
NAVARRA: 31, 66

***Macbrideola synsporos* (Alexop.) Alexop.**
BALEARES: 92

***Metatrichia vesparium* (Batsch) Mann.-Brem.**
= *Hemitrichia vesparium* (Bastsch) T. Macbride
ALAVA: 1
CACERES: 46, 55
GERONA: 41
GUIPUZCOA: 101
LERIDA: 41
NAVARRA: 31, 37, 66, 108
CANARIAS: 27, 46, 55
PAIS VASCO: 68, 104

Mucilago crustacea* Wigg. var. *crustacea
= *Mucilago spongiosa* (Leyss.) Morgan
= *Spumaria alba* (Bull.) DC.
ALAVA: 1
ALBACETE: 41, 49, 77
AVILA: 58, 65
BARCELONA: 39, 41, 76
CACERES: 46, 55
GERONA: 52
GUADALAJARA: 55, 87
GRANADA: 36, 71, 84, 89, 90
LERIDA: 52, 75
MADRID: 53, 57, 58, 64, 67, 87, 111
MURCIA: 41, 48, 54
NAVARRA: 31, 66
TARRAGONA: 41
VALENCIA: 34, 77
VIZCAYA: 82 (as *Fuligo cinerea*, obs. pers.)
BALEARES: 40, 41
CASTILLA LA NUEVA: 110
GALICIA: 115
PAIS VASCO: 68

***Mucilago crustacea* var. *solida* (Sturgis) Lister**
MADRID: 58, 61

***Oligonema fulvum* Morgan**
SORIA: 91

***Paradiacheopsis cribata* Mann.-Brem.**
CANARIAS: 27

***Paradiacheopsis fimbriata* (G. Lister & Cran) Hertel**
BARCELONA: 83
GERONA: 83

***Paradiacheopsis rigida* (Brandza) Mann.-Brem.**
CANARIAS: 26

***Paradiacheopsis solitaria* (Mann.-Brem.) Mann.-Brem.**
BARCELONA: 83
BALEARES: 92
CANARIAS: 26

***Perichaena chrysosperma* (Currey) Lister**
ALICANTE: 41
CACERES: 46, 55
GERONA: 39, 41
TARRAGONA: 41
CANARIAS: 27, 30

***Perichaena corticalis* (Batsch) Rostaf.**
ALBACETE: 41, 49
ALICANTE: 41
AVILA: 58, 65

GERONA: 39, 41
GUADALAJARA: 65
LERIDA: 41
MADRID: 53, 57, 58, 64, 67
MURCIA: 41, 48, 54
SEGOVIA: 58, 65
ZAMORA: 65
CANARIAS: 27

Perichaena depressa **Libert**
BARCELONA: 41
CACERES: 46, 55
CORUÑA: 65
MURCIA: 41, 48, 54
TARRAGONA: 41
CANARIAS: 26
GALICIA: 116

Perichaena minor **(G. Lister) Hagelst.**
ALICANTE: 41
CACERES:46 and 55 (cited as *Perichaena pedata*, obs. pers.)
GERONA: 41
MURCIA: 48, 54
VALENCIA: 41
BALEARES: 40, 41

Perichaena vermicularis **(Schwein.) Rostaf.**
ALBACETE: 41, 49
ALICANTE: 41
AVILA: 58, 64
BURGOS: 91, 94
GUADALAJARA: 91, 94
LERIDA: 41
MADRID: 57, 58, 64, 67
SEGOVIA: 58, 65, 91
SORIA: 91, 94
TARRAGONA: 39
BALEARES: 92
CANARIAS: 26
GALICIA: 116

Physarum aeneum **R.E.Fries**
CANARIAS: 27

Physarum alpinum **(Lister & G. Lister) G. Lister**
MADRID: 57, 58, 67
TARRAGONA: 41

Physarum auriscalpium **Cooke**
BARCELONA: 41, 83
MADRID: 58, 88

Physarum bethelii **T. Macbride**
ALBACETE: 73
GRANADA: 36, 71, 90
MURCIA: 73

Physarum bitectum **G. Lister**
ALBACETE: 41
ALICANTE: 41 (it correponds to *Diderma spumaroides*, 58)
AVILA: 58, 65
CACERES: 46, 55
GRANADA: 89
MADRID: 58, 65
BALEARES: 41
CANARIAS: 27

Physarum bivalve **Pers.**
= *Physarum sinuosum* (Bull). Weinm.
AVILA: 58, 65
BARCELONA: 41
CACERES: 46, 55
GERONA: 41
MADRID: 58, 101

Physarum bogoriense **Racib.**
CACERES: 46, 55

Physarum brunneolum **(Phill.) Massee**
ALICANTE: 41
AVILA: 58, 59
MADRID: 58, 59
MURCIA: 41, 48, 54

Physarum cinereum **(Batsch) Pers.**
AVILA: 58, 65
BARCELONA: 41
LERIDA: 75
MADRID: 32, 33, 53, 55, 58, 87
MURCIA: 73

SEGOVIA: 58, 65
BALEARES: 41
CANARIAS: 27
GALICIA: 116

Physarum compressum Alb. & Schwein.
ALICANTE: 41
CASTELLON: 55, 87
GERONA: 39, 41
MADRID: 46, 48, 55, 58, 87, 101
MURCIA: 41, 48, 54,70
TARRAGONA: 41
BALEARES: 40, 41
CANARIAS: 6, 27

Physarum conglomeratum (Fr.) Rostaf.
GRANADA: 36, 89
GUADALAJARA: 59

Physarum contextum (Pers.) Pers.
CACERES: 46, 55
GRANADA: 36
MADRID: 15, 58, 61,80

Physarum crateriforme Petch.
CANARIAS: 27
GALICIA: 115

Physarum decipiens M. A. Curtis
BARCELONA: 39, 41, 51
MURCIA: 41, 51
SORIA: 91, 93 (they consider *P. decipiens* and *P. auriscalpium* as synonymous).
BALEARES: 92
CANARIAS: 27, 54

Physarum diderma Rostaf.
GUADALAJARA: 88
MURCIA: 73

Physarum didermoides (Pers.) Rostaf.
CANARIAS: 27

Physarum globuliferum (Bull.) Pers.
CANARIAS: 26

Physarum leucophaeum Fr.
= *Physarum nutans var. leucophaeum* Lister
ALBACETE: 73
AVILA: 58, 65
CACERES: 46, 55
GRANADA: 36
MADRID: 9, 32, 46, 53, 55, 57, 58, 67, 84, 87
MURCIA: 73
NAVARRA: 31, 66
SEGOVIA: 28, 58
BALEARES: 40, 41, 96
CANARIAS: 3, 27
GALICIA: 116
PAIS VASCO: 68

Physarum leucopus Link.
MURCIA: 73

Physarum limonium Nann.-Brem.
CANARIAS: 27

Physarum listeri T. Macbride
MURCIA: 41, 50, 54
TOLEDO: 50

Physarum lividum Rostaf.
MADRID: 85
CANARIAS: 69 (it corresponds to *Physarum spectabile*, 44)

Physarum luteolum Peck
BARCELONA: 41
GERONA: 41
MADRID: 58, 61

Physarum melleum **(Berk. & Br.) Massee**
BARCELONA: 41
BALEARES: 40, 41

Physarum mortonii **T. Macbride**
GUADALAJARA: 117 (as *Physarum sulphureum*, 20)
CANARIAS: 69

Physarum mutabile **(Rostaf.) G. Lister**
MADRID: 57, 58, 67
CANARIAS: 69

Physarum newtonii **T. Macbride**
BARCELONA: 41
MURCIA: 41

Physarum notabile **T. Macbride**
BALEARES: 92

Physarum nudum **T. Macbride**
GUADALAJARA: 13
MADRID: 58
SEGOVIA: 58

Physarum nutans **Pers.**
= *Tilmadoche nutans* (Pers.) Rostaf.
ALAVA: 1
ALBACETE: 49, 41
ALICANTE: 41
AVILA: 55, 58, 87, 65
BADAJOZ: 55, 46
BARCELONA: 41, 77, 83
CACERES: 55, 46
GRANADA: 36, 71, 90
GUADALAJARA: 13
LERIDA: 41
MADRID: 28, 46, 53, 55, 57, 58, 67, 87
MURCIA: 41, 48, 54, 70
NAVARRA: 4, 31, 37, 66, 109
PONTEVEDRA: 46, 55, 113
SEGOVIA: 28, 58
TARRAGONA: 39, 41
BALEARES: 40, 41, 78, 96
CANARIAS: 27, 69
GALICIA: 115
PAIS VASCO: 68, 104

Physarum oblatum **T. Macbride**
BARCELONA: 83
GUADALAJARA: 91, 94

Physarum ovisporum **G. Lister**
MADRID: 88 (cited as *Badhamia macrocarpa*, 67)
CANARIAS: 27

Physarum perfectum **Peck**
MADRID: 58, 88

Physarum pezizoideum **(Jungh). Pav. & Lag. var. pezizoideum**
MADRID: 2

Physarum pezizoideum **var. microsporum Farr**
GUADALAJARA: 55, 87
MADRID: 58, 88

Physarum pulcherripes **Peck**
GUIPUZCOA: 101
PAIS VASCO: 68, 104

Physarum pusillum **(Berk. & M.A. Curtis) G. Lister**
ALBACETE: 49, 41
AVILA: 58, 61
BARCELONA: 83
MADRID: 55, 58, 87, 61
MURCIA: 41, 48, 54
SORIA: 91, 94
TARRAGONA: 41
VALENCIA: 41
BALEARES: 40, 41
CANARIAS: 27

Physarum robustum **(Lister) Nann.-Brem.**
ALBACETE: 73
AVILA: 58, 61
BADAJOZ: 46, 55
MADRID: 58, 61
PONTEVEDRA: 113
CANARIAS: 27
GALICIA: 116

Physarum roseum **Berk. & Br.**
CANARIAS: 6, 27, 103
GALICIA: 115

Physarum rubiginosum **Fr.**
GALICIA: 116

Physarum serpula **Morgan**
MURCIA: 41, 48
BALEARES: 92
CANARIAS: 27, 54

Physarum spectabile **Nann.-Brem., Lado & Moreno**
CANARIAS: 44 (as *Physarum lividum*, 69)

Physarum spinisporum **Eliass. & Lundq.**
CANARIAS: 30

Physarum straminipes **Lister**
ALBACETE: 70
CASTELLON: 55, 87
GUADALAJARA: 61
MADRID: 53, 55, 58, 61, 87
MURCIA: 41, 54, 70
SEGOVIA: 58, 61
VALENCIA: 41
CANARIAS: 26

Physarum sulphureum **Alb. & Schwein.**
= *Physarum variabile* Rex
GUADALAJARA: 20 (it corresponds to *Physarum mortonii*, 117)

Physarum vernum **Sommerf.**
ALBACETE: 73
AVILA: 58, 65
BARCELONA: 39
CANARIAS: 26
CASTELLON: 55, 87
GRANADA: 36
GUADALAJARA: 65, 91, 94
MADRID: 55, 58, 65, 87
MURCIA: 73
PONTEVEDRA: 113
SEGOVIA: 58, 65
GALICIA: 116

Physarum virescens **Ditmar**
GERONA: 39, 41
CANARIAS: 27

Physarum viride **(Bull.) Pers.**
ALBACETE: 73
AVILA: 58, 65
CACERES: 46, 55
GERONA: 39, 41
MADRID: 57, 58, 67
MURCIA: 73
PONTEVEDRA: 113
SEGOVIA: 107
CANARIAS: 3, 27, 106
GALICIA: 116

Physarum xanthinum **Nann.-Brem. & Döebbeler**
BARCELONA: 41

Prototrichia metallica **(Berk.) Massee**
ALBACETE: 49
ALICANTE: 41
LERIDA: 39, 41
CANARIAS: 26

Stemonitis axifera **(Bull.) T. Macbride**
= *Stemonitis ferruginea* Ehrenb.
= *Stemonitis fasciculata* Pers.

ALAVA: 1
BARCELONA: 83
CACERES: 46, 55
CADIZ: 38, 110
CIUDAD REAL: 107
GERONA: 39, 41
MADRID: 58, 65
MURCIA: 73
CANARIAS: 6, 27, 103
PAIS VASCO: 68, 104

Stemonitis emotoi **Nann.-Brem. & Yamam.**
SORIA: 91

Stemonitis flavogenita **Jahn.**
ALAVA: 1
CACERES: 46, 55
MADRID: 57, 67
MURCIA: 41, 54
NAVARRA: 102
CANARIAS: 26
PAIS VASCO: 68

Stemonitis fusca **Roth.**
= *Stemonitis fasciculata* Pers.
ALAVA: 1
ALBACETE: 41, 49
AVILA: 58, 65, 84
BADAJOZ: 46, 55
BARCELONA: 39, 41, 76
CACERES: 46, 55
CIUDAD REAL: 55, 87, 107
CORUÑA: 65
GERONA: 39, 41, 83
GUADALAJARA: 65
GUIPUZCOA: 68
LERIDA: 41
MADRID: 2, 28, 57, 58, 67
MURCIA: 41, 48
NAVARRA: 4, 31, 37,66
PONTEVEDRA: 113
SALAMANCA: 65
SEGOVIA: 58, 65
CANARIAS: 27
CATALUÑA: 52
GALICIA: 116
PAIS VASCO: 68, 104

Stemonitis herbatica **Peck**
GERONA: 98
BALEARES: 40, 41

Stemonitis microsperma **B. Ing**
CANARIAS: 27

Stemonitis nigrescens **Rex**
AVILA: 58, 60
MADRID: 58, 60
NAVARRA: 31, 66
PONTEVEDRA: 113
SEGOVIA: 91, 94
BALEARES: 40, 41
CANARIAS: 27
GALICIA: 116

Stemonitis pallida **Wingate**
MURCIA: 73

Stemonitis smithii **T. Macbride**
GERONA: 41
PONTEVEDRA: 113
GALICIA: 115, 116

Stemonitis splendens **Rostaf. var.** ***splendens***
ALAVA: 1
BARCELONA: 41
CANARIAS: 27
PAIS VASCO: 68, 104

Stemonitis splendens **Rostaf. var.** ***webberi*** **(Rex) Lister**
CASTELLÓN: 46, 55

Stemonitis uvifera **T. Macbride**
GALICIA: 116

Stemonitis virginiensis **Rex**
BARCELONA: 41, 51
CACERES: 46, 55
CIUDAD REAL: 55, 87
GUADALAJARA: 55, 87
MADRID: 58, 61
MURCIA: 41, 51, 54

NAVARRA: 31, 66
BALEARES: 41, 51
GALICIA: 116
PAIS VASCO: 68

***Stemonitopsis amoena* (Nann.-Brem.) Nann.-Brem.**
ALBACETE: 73
MADRID: 58 (part of it cited as *Comatricha dictyospora*, 57, 62, 67), 61
PONTEVEDRA: 113
GALICIA: 116

***Stemonitopsis hyperopta* (Meyl.) Nann.-Brem.**
=*Stemonitis hyperopta* Meyl.
MADRID: 58 (part of it cited as *Comatricha dictyospora*, 57, 62, 67)
PONTEVEDRA: 113
GALICIA: 116

***Stemonitopsis typhina* (Wigg.) Nann.-Brem.**
= *Stemonitis typhina* Wigg.
= *Comatricha typhina* (Wigg.) Rostaf.
= *Comatricha typhoides* (Bull.) Rostaf.
BADAJOZ: 46, 55
CACERES: 46, 55
GUADALAJARA: 62
MADRID: 57, 67, 58 (cited as *Comatricha pulchella*, 67)
SEGOVIA: 28, 58, 60
CANARIAS: 27
PAIS VASCO: 68

***Symphytocarpus amaurochaetoides* Nann.-Brem.**
SEGOVIA: 58, 59

***Symphytocarpus flaccidus* (Lister) Ing & Nann.-Brem.**
= *Stemonitis splendens* var. *flaccida* A. Lister
ALBACETE: 41
AVILA: 55, 84
CACERES: 46, 55
MADRID: 46, 55, 58, 59, 84, 87
SEGOVIA: 58, 59
GALICIA: 115, 116

***Symphytocarpus impexus* Ing & Nann.-Brem.**
GRANADA: 36, 71, 90
SEGOVIA: 58, 60

***Trichia affinis* de Bary**
BARCELONA: 12
MADRID: 58, 60
PAIS VASCO: 68

***Trichia botrytis* (J.F. Gmelin) Pers.**
ALBACETE: 41, 49
GERONA: 41
MADRID: 32, 33, 57, 58, 60, 67
MURCIA: 41, 48, 54
SALAMANCA: 55, 60
SEGOVIA: 28, 58
CANARIAS: 6, 27, 109
GALICIA: 116
PAIS VASCO: 68

Trichia contorta* (Ditmar) Rostaf. var. *contorta
ALBACETE: 41, 49
AVILA: 58, 60
BURGOS: 60
CACERES: 46
GRANADA: 36, 90
GUADALAJARA: 13, 60
MADRID: 57, 58, 60, 62, 67
MURCIA: 41, 48, 54
SEGOVIA: 58, 60
BALEARES: 40, 41
CANARIAS: 27

***Trichia contorta* var. *attenuata* Meyl.**
AVILA: 58, 60
MADRID: 60
SEGOVIA: 58, 60

***Trichia contorta* var. *iowensis* (T. Macbride) Torrend**
BURGOS: 91, 94
SEGOVIA: 58, 60

Trichia contorta var. ***karstenii*** (Rostaf.) Ing
BURGOS: 91, 94
CACERES: 55
GUADALAJARA: 60, 91, 94
MADRID: 58, 60
SORIA: 91, 94
CANARIAS: 26

Trichia decipiens (Pers.) T. Macbride var. ***decipiens***
ALBACETE: 41, 49
AVILA: 58, 60
BADAJOZ: 46, 55
BARCELONA: 41, 83
CACERES: 46, 55
GERONA: 83
GRANADA: 36, 71
GUADALAJARA: 13
LERIDA: 41
MADRID: 28, 32, 55, 58, 60, 62, 64, 67
MURCIA: 41, 48, 54
NAVARRA: 31, 37, 66
SALAMANCA: 60
SEGOVIA: 28, 58
CANARIAS: 27
PAIS VASCO: 68, 104

Trichia decipiens var. ***olivacea*** Meyl.
CACERES: 46, 55
MADRID: 60
NAVARRA: 66

Trichia favoginea (Batsch) Pers.
= *Trichia chrysosperma* (Bull.) Lam. & DC.
ALAVA: 1
BARCELONA: 39, 41
GERONA: 41
MADRID: 57, 58, 62, 67, 107
NAVARRA: 4, 29, 31, 37, 66
GALICIA: 116
PAIS VASCO: 68, 104

Trichia flavicoma (Lister) Ing
CACERES: 46, 55

Trichia floriformis (Schwein.) G. Lister
PONTEVEDRA: 113
CANARIAS: 27
GALICIA: 116

Trichia lutescens (Lister) Lister
GUADALAJARA: 60
MADRID: 57, 67
MURCIA: 41, 48, 54
CANARIAS: 26, 69
GALICIA: 116

Trichia munda (Lister) Meyl.
CANARIAS: 27

Trichia persimilis Karsten
BADAJOZ: 46, 55
BARCELONA: 12, 25
CACERES: 46, 55
CANARIAS: 27

Trichia scabra Rostaf.
BARCELONA: 25, 41
GERONA: 41
LERIDA: 41
SEGOVIA: 58, 60
GALICIA: 116
PAIS VASCO: 68

Trichia subfusca Rex
SALAMANCA: 64

Trichia varia (Pers.) Pers.
= *Trichia ovata* Pers.
ALAVA: 1
ALBACETE: 41, 49
ALICANTE: 41
AVILA: 58, 60
BARCELONA: 12, 35, 39, 41, 76, 83
BURGOS: 60
CACERES: 46, 55
GERONA: 41, 83
GRANADA: 36, 90
GUADALAJARA: 60
LERIDA: 41
MADRID: 28, 32, 53, 55, 57, 58, 60, 67, 80, 87
NAVARRA: 10, 31, 66
SEGOVIA: 58, 60
CANARIAS: 6, 27, 109
GALICIA: 116

PAIS VASCO: 68, 104

Tubifera ferruginosa **(Batsch) J.F. Gmelin**
ALAVA: 1
ALBACETE: 41, 49
AVILA: 46, 55, 58, 65
BARCELONA: 41
CACERES: 46
GERONA: 39, 41, 75
GUADALAJARA: 65
MADRID: 57, 58, 67
MURCIA: 41, 48, 54
NAVARRA: 37, 108
SEGOVIA: 55, 58, 65, 87
VIZCAYA: 82
CANARIAS: 3, 26
PAIS VASCO: 68, 104

Tubifera papillata **Martin, Thind & Sohi**
NAVARRA: 31, 66

WORKS USED TO ELABORATE THIS CATALOGUE

1.- The list wich follow correspond to the authors and year of the paper in which each record is found.

2.- For the numerical relation an alphabetical order has been follow although, unfortunatelly, not always has been possible.

1.- ANóNIMO (1976)
2.- ARRANZ (1989)
3.- BAñARES (1988)
4.- GARCíA-BONA (1979)
5.- BARRASA (1978)
6.- BELTRAN (1976)
7.- BELTRAN & al. (1987)
8.- BELLOT (1952)
9.- BENITO-MARTINEZ (1931)
10.- BENITO-MARTINEZ & GUINEA (1931)
11.- BERTAULT (1974)
12.- BERTAULT (1982)
13.- BLANCO & MORENO (1986)
14.- BOTEY (1923)
15.- CABALLERO (1928)
16.- CALONGE (1968)
17.- CALONGE (1974)
18.- CALONGE (1986)
19.- CALONGE & ZUGAZA (1973)
20.- CALONGE & ABELLA (1979)
21.- CALONGE & TELLERíA (1980)
22.- CALONGE & ORIA DE RUEDA (1988)
23.- CALONGE & al. (1978)
24.- CARBALLAL (1975)
25.- CUATRECASAS (1925)
26.- CHAMPION (1983)
27.- CHAMPION & BELTRAN (1980)
28.- CHECA & al. (1982)
29.- EDERRA & al. (1980)
30.- ELIASSON & LUNDQUIST (1979)
31.- ELVIRA (1987)
32.- ESTEVE-RAVENTóS (1983)
33.- ESTEVE-RAVENTóS & MORENO (1984)
34.- FOLGADO & al. (1984)
35.- FONT-QUER (1923)
36.- GALAN & al. (1984
37.- GARCíA-BONA (1987)
38.- COLMEIRO (1889)
39.- GRACIA (1977)
40.- GRACIA (1979)
41.- GRACIA (1981)
42.- GRACIA (1983)
43.- GRACIA (1986)
44.- NANNENGA-BREMEKAMP & al. (1984)
45.- GRACIA (1987a)
46.- MORENO & al. (1990)
47.- GRACIA (1987b)
48.- GRACIA & LLIMONA (1980)
49.- GRACIA & al. (1981)
50.- GRACIA & al. (1982)
51.- GRACIA & al. (1983)
52.- HEIM & al. (1934)
53.- HEYKOOP & al. (1988)
54.- HONRUBIA & al. (1984)
55.- ILLANA (1989)
56.- KELLER & BROOKS (1977)
57.- LADO (1978)
58.- LADO (1984)
59.- LADO (1985a)
60.- LADO (1985b)
61.- LADO (1987)
62.- LADO & MORENO (1976)
63.- LADO & MORENO (1977)
64.- LADO & MORENO (1978)
65.- LADO (1986)
66.- ELVIRA (1985)
67.- LADO & MORENO (1980)
68.- LADO & MORENO (1981a)
69.- LADO & MORENO (1981b)
70.- LóPEZ-SANCHEZ & al. (1986c)

71,- LADO & al, (1980)
72,- LAZARO-IBIZA (1912)
73,- LóPEZ-SANCHEZ & al, (1986a)
74,- LóPEZ-SANCHEZ & al, (1986b)
75,- MAIRE (1937)
76,- MAIRE & al, (1933)
77,- MALENÇON & BERTAULT (1971)
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80,- MAS-GUINDAL (1945)
81,- MAUBLANC (1936)
82,- MENDAZA & DIAZ (1987)
83,- LLISTOSELA & AGUASCA (1986)
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89,- ORTEGA & CALONGE (1980)
90,- ORTEGA & BUENDíA (1986)
91,- PANDO (1986)
92,- PANDO (1989)
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94,- PANDO & LADO (1987b)
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96,- ROLLAND (1905)
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99,- SOCIETAT CATALANA DE MICOLOGIA (1986)
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101,- TORRE & CALONGE (1975)
102,- URRIES (1953)
103,- WILDPRET & BELTRAN (1974)
104,- ANóNIMO (1981)
105,- GARCíA-BONA (1980)
106,- BAÑARES & BELTRAN (1987)
107,- GARCíA-MANJóN (1978)
108,- GARCíA-BONA (1982)
109,- GARCíA-BONA (1989)
110,- COLMEIRO (1867)
111,- LAZARO-IBIZA (1903)
112,- GARCíA-BONA (1978)
113,- PORTELA & LADO (1989)
114,- SIQUIER & CONSTANTINO (1982)
115,- CASTRO & al, (1986)
116,- CASTRO & FREIRE (1988)
117,- CALONGE (1980)

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ARGUMENTS FOR DIAGNOSES BASED ON UNALTERED WALL STRUCTURES

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ABSTRACT

Spore wall terminology generally accepted for vesicular-arbuscular mycorrhizal fungi now includes types that are the result of reactions of certain walls to mountants. Spore diagnoses based on wall reactions are not compatible with the morphology of unaltered spores. Type specimens altered by mountants or preservatives do not represent the morphology of the species. Arguments are presented for diagnoses based on the morphology of fresh spores suspended in water.

RESUMO

A terminologia geralmente aceita para descrever as estruturas parietais de fungos micorrízicos vesiculares-arbusculares, inclue atualmente tipos que sâo a resultante de reaçôes de certas paredes aos montantes. As diagnoses de esporos baseadas em reaçôes das paredes nâo sâo compativeis com a morfologia de esporos inalterados. Os especimens de referencia alterados pelos montantes ou preservativos nâo representam a morfologia da especie propriamente dita. Argumentos sâo apresentados, neste trabalho, para a realizaçâo de diagnoses baseadas na morfologia de esporos frescos suspensos em âgua.

A standardized terminology for wall structures, proposed by Walker (1983) for the Endogonaceae, has been widely adopted for spore descriptions of VA mycorrhizal fungi. Four morphological wall types (evanescent, laminated, membranous and unit) were recognized initially. Two wall types subsequently described were reagent-dependent (non-aqueous): expanding (Berch and Koske, 1986) and amorphous (Morton, 1986a); a third type, the coriaceous wall (Walker, 1986), was reagent-dependent for the 'coriaceous' effect, however, the reaction was not essential for recognition of the wall type. Wall anomalies resulting from reactions to mountants and/or preservatives give validity to arguments for diagnoses based on unaltered wall structures: the morphology of fresh spores suspended in water.

The interpretation of wall reactions as spore 'morphology' is questionable. The amorphous wall and the expanding wall are unit walls (Morton, 1988). The reaction producing the amorphous wall character is pH dependent; it "...appears as a rigid unit wall" in water (Morton, 1986b) and becomes plastic only in mountants with a pH less than 2.0 (Morton, 1988). The expanding wall phenomenon occurs when the outer wall of Glomus pansihalos comes into contact with lactic acid (Berch and Koske, 1986) or other acidic mountants (Morton, 1988). The reaction also causes the outer wall, hyaline 3-5(-15)µm in water mount, to become granular (Berch and Koske, 1986). The coriaceous wall, a thick pliable wall in water, exhibits a leathery character only in hypertonic solutions, if at all (Walker, 1986).

The term 'membranous' described relatively thin and flexible inner walls which often wrinkle and collapse in hypertonic solutions (Walker, 1983). Reactions aside, thickness parameters separated the two pliable wall types. The coriaceous wall, 2-5µm thick, was contrasted with a normal membranous wall usually no more than 1 or 2µm thick and often less than 1µm. Although they could be treated as an entity since the measurements are a continuum (thickness parameters would indicate a very thin or a robust pliable wall), their structure in water allows for separation. A ruptured membranous wall, very thin and filmy, is distinguishable from a pliable wall with more consistency. Thickness parameters define pliable walls that adhere to rigid walls in water. Walker (1986) indicated that the coriaceous wall had some characteristics of both unit and membranous walls; the term 'pliable unit wall' was suggested to replace 'coriaceous wall' (Spain et al., 1989).

The description of Scutellospora biornata (Spain et al., 1989) illustrates the problem of using both morphology and reactions for defining wall types. The diagnosis was based on observations and wall measurements of spores suspended in water. The laminated wall (wall 2) was not remarkable in water, however, it reacted to lactophenol and polyvinyl alcohol-lactophenol (PVL) by expanding; the laminae, often barely discernible, occasionally dissolved. The altered wall was not considered to be a new wall type. Wall 3, a very thin inner ornamented wall, tightly adhered to laminated wall 2; it was interpreted to be a membranous wall rather than a unit wall as it wrinkled near the periphery when intact spores suspended in water were broken by pressure on the cover slip. The germination shield formed between walls 5 and 6; the aperture appeared in wall 6. Membranous wall 5 (<0.5-1µm) and wall 6 (1-2 µm) together had a coriaceous appearance when ruptured in water and lactophenol; the former wrinkled and adhered somewhat loosely to the latter. Wall 6 lacked a 'coriaceous' character in water, lactophenol and PVL. It was not robust (1-2µm thick); otherwise it met criteria for a coriaceous wall: rather tough and flexible. Wall 6 was described as a pliable unit wall to avoid using a reaction as a morphological wall type; it was depicted in the murograph as a unit wall leaving the problem unresolved.

Numerous researchers (Berch and Fortin, 1983; Schenck et al., 1984; Morton, 1986a; Berch and Koske, 1986) have called attention to the problems caused by mountants and/or preservatives by including measurements of spore walls in water and documenting alterations caused by reagents in species descriptions. Morton described three new Acaulospora species each with a unit wall that reacted with mountants by becoming plastic. Koske and Walker (1986) reported the same reaction for the innermost wall of S. pellucida and Morton (1988) noted that the reaction had gone unrecognized in walls described as membranous (*A*. *morrowae* and *Entrophospora colombiana*). This suggests the magnitude of the problem. Reactions to common mountants and preservatives are varied: wall thickness measurements can be significantly altered and wall character can change (Berch and Fortin, 1983; Schenck et al., 1984; Berch and Koske, 1986; Koske and Walker, 1986; Morton, 1986a, b, 1988); granules can disappear (Morton, 1986b) or appear (Berch and Koske, 1986); group composition can change (Morton, 1986b); walls can fuse (Koske and Walker, 1986) or dissolve (Berch and Koske, 1986; Spain et al., 1989).

Dissection, although tedious, is often preferable to squashing for elucidating wall affinities and features of certain spores. It is an especially useful technique for discerning the wall morphology of spores suspended in water or Melzer's reagent: spore contents can obscure fracture/rupture sites; opaque outer walls hide inner walls; and strong reactions to Melzer's reagent mask weaker reactions. If necessary, wall type can be determined or confirmed by staining or special microscopy (e.g. a hyaline, finely laminate wall). Observations of wall reactions to phenol, lactic acid or other reagents aid in spore identification (e.g. *G*. *pansihalos*, also distinctive due to an ornamented wall) or define a group within a genus (e.g. spores with rigid walls that are plastic in a given reagent).

Spore diagnoses made from altered specimens (mounted or preserved in reagents which distort) are not compatible with observations of spores suspended in water or observations made of recently mounted or preserved material before wall alterations become evident. Nicolson and Schenck (1979) described *S*. *pellucida* as having "...two separable walls, the outer wall, brittle, of two to three laminae"; ultrastructural studies by Gibson (1985), cited by Morton (1988), of fixed spores revealed 2-3 walls. *Scutellospora pellucida* has been redescribed by Koske and Walker (1986) as having six walls. The author was unable to discern six walls in the type slide of S. pellucida (mounted in lactophenol) loaned by OSC.

The lack of agreement between preserved or stored type specimens and fresh or very recently mounted spores will become more obvious as researchers compare descriptions of altered walls or wall groups with unaltered specimens (culto-types maintained in the International Culture Collection of VA Mycorrhizal Fungi [INVAM] or in other collections). Redescriptions of type specimens with altered walls for the purpose of emending diagnoses or standardizing wall terminology pose a serious problem especially if walls fused in the medium used for preservation. This event is suggested, for example, in the comparison of the type material and the diagnosis of Glomus aggregatum Schenck and Smith emend. Koske (Koske, 1985). Schenck and Smith (1982) described the spore as having two walls, an outer wall slightly thicker and lighter than the inner wall, separable with slight pressure; a majority of spores possessed a single wall in the type material examined by Koske. Where possible fresh spores of the same type should be mounted in water and described to determine if the walls of the preserved spores have been altered. It may not be possible to discern from diagnoses whether alterations took place before or after descriptions were made. In the absence of a mountant or fixative that preserves wall integrity it is necessary to describe spore walls suspended in water and note anomalies caused by reactions to mountants recognizing that the type specimen of a species may no longer reflect the morphology of unaltered spores.

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NOTEWORTHY SPECIES OF HYPOCREA, HYPOMYCES, AND THUEMENELLA (ASCOMYCETES, HYPOCREALES) FROM WISCONSIN

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SUMMARY

Four interesting species of Hypocreales were recently collected during a long-term study of higher fungi at several sites in Wisconsin. *Hypocrea latizonata*, *Hypomyces chrysostomus*, *Hypomyces tremellicola*, and *Thuemenella cubispora* are reported as new records from the state, and their distribution ranges in North America are significantly extended. The first three species are mycoparasitic; the fourth is saprotrophic on dead hardwood logs and branches.

Hypocrea latizonata Peck ex Ellis & Everh.

Parasitizes the common and widely distributed bird's nest fungus *Cyathus striatus*, and is apparently restricted to this single host. The parasite stroma forms a broad band around the outer surface of the host basidiome. Stromata are at first white, changing to a light tan as the perithecia mature. Illustrations are found in Brodie (1975), Brunel (1952), Lohman (1938), Martin (1942), and Sundberg and Kost (1989).

The name *Hypocrea latizonata* was originally proposed by Peck, but was first published by Ellis and Everhart (1886) from material collected by A.P. Morgan in Ohio. Additional records include Indiana (Lohman, 1938), Iowa (Martin, 1942; Fitzgerald, 1949), and Illinois (Cooke, 1969; Sundberg and Kost, 1989). Brunel (1952) made the first collection from Canada (Ontario), and cited two collections from New York by Peck and two from North

Carolina by Thaxter.

Wisconsin collection: La Crosse Co., Helga Gunderson Arboretum, 21 IX 1979, A.& D. Parker. Thirty-three infected basidiomes of Cyathus striatus were collected during the fifth annual A.H. Smith Lakes States Foray. Specimens deposited at BPI, FH, and NY.

Hypomyces tremellicola (Ellis & Everh.) Rogerson in Samuels

Most commonly parasitic on basidiomes of the agaric genus Crepidotus; also reported on Polyporus spp. and Pleurotus sp. (Samuels, 1976). During the early stages of infection on Crepidotus, the white mycelium spreads over both cap and gills of the host. At maturity, the brownish-yellow perithecia are embedded in a light tan subiculum. When mature, the parasite causes major distortion of the host basidiome, but the gill edges are usually evident.

Hypomyces tremellicola was first described by Ellis and Everhart (1892) from a collection made by A.P. Morgan in Ohio. Recent reports include Illinois (Cooke, 1969), Indiana (Cooke, 1975), Louisiana (Lowy & Cooke, 1965), and Massachusetts (Cooke, 1967). These collections, all on Crepidotus sp., were made by C.T. Rogerson during Mycological Society of America annual forays. Rogerson (Samuels, 1976) has also examined material from Kansas, Maryland, Michigan, New York, North Carolina, Ohio, Pennsylvania, and Quebec, Canada.

Wisconsin collections: Fond du Lac Co., Mauthe Lake Recreation Area, 27 VIII 1988, A. Parker; Ozaukee Co., UW-Milwaukee Field Station, 28 VIII 1987, A. Parker; Sauk Co., Aldo Leopold Memorial Reserve, 5 IX 1987, A. Parker. Specimens deposited at BPI and NY.

Hypomyces chrysostomus Berk. & Broome Fig. 1

Parasitic on Ganoderma applanatum and apparently restricted to this single host. The parasite mycelium forms a thick, grayish-brown, fan-shaped subiculum over the host pore surface. Bundles of radiating hyphae give the subiculum a feathery appearance; hyphae are sometimes cream-colored toward the center of the subiculum. Perithecia are slow to develop; most collections are infertile (Rogerson, pers. comm.).

Hypomyces chrysostomus was originally described by Berkeley and Broome (1873) from Ceylon. The only illustration of the entire subiculum appears in Lloyd's (1915) Mycological Note No. 39, page 539, as Sebacina dendroidea. Lloyd noted that he had received specimens from Ohio, Massachusetts, New York, and Pennsylvania. All material must have been sterile since Lloyd assumed the species to be a Basidiomycete. The only recent report from North America is a collection made by Cornell mycologists and C.T. Rogerson during the 1952 Mycological Society of America foray near Ithaca, New York (Mix, 1954). Although rarely reported, H. chrysostomus is fairly common on Ganoderma applanatum in Wisconsin and Illinois. A possible explanation for the small number of reports is that the host is very common, easily identified, and often ignored by mycologists.

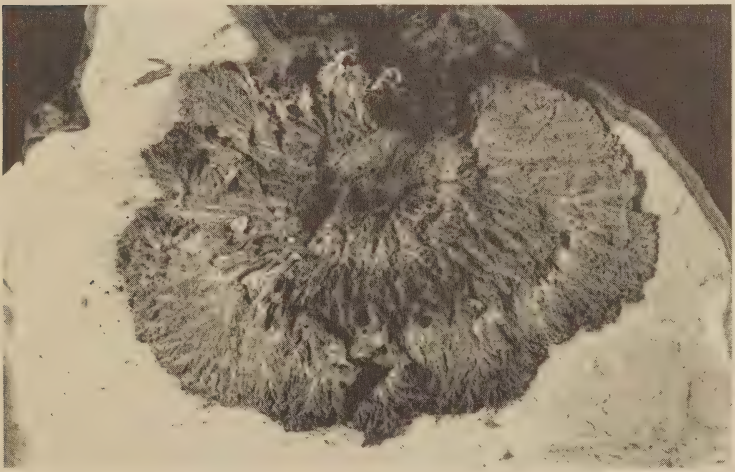

Fig. 1. Hypomyces chrysostomus subiculum on the pore surface of Ganoderma applanatum, X 0.9.

Wisconsin collections: Fond du Lac Co., Mauthe Lake Recreation Area, 10 IX 1988, A. Parker; Kenosha Co., Brighton Dale County Park, 11 X 1986 and 4 X 1987, A.& D. Parker; Ozaukee Co., UW-Milwaukee Field Station, 25 IX 1986 and 6 IX 1987, A. Parker; Waukesha Co., Muskego County Park, 17 IX 1983 and 11 IX 1986, A. Parker; Waukesha Co., Norman Chester Scientific Area, 14 IX 1985 and 20 IX 1986, A. Parker; Waukesha Co., UW-Waukesha Field Station, 18 VIII 1977, A. Parker.

Thuemenella cubispora (Ellis & Holw.) Boedijn

Collections from Wisconsin were made from mid-August through September on decorticated hardwood logs and small hardwood branches. *Thuemenella cubispora* forms small, bright lemon-yellow stromata (0.5-2.5 cm dia., 0.5-1.0 cm high) which tend to coalesce into compound stromata with a convoluted surface. At maturity the surface is uniformly dotted with perithecial ostioles; perithecia develop in a single layer just beneath the surface. The stromata turn brownish-black as discharged ascospores accumulate on the surface; at this stage the ascocarps may be overlooked or mistaken for a member of the Xylariaceae. The stromata are illustrated in Mycotaxon 12: 505 (Candoussau, 1981) and Mycologia 73: 48 (Rogers, 1981); 77: 274 (Corlett, 1985).

Thuemenella cubispora is widely distributed, although rarely collected. It was originally described as *Hypocrea cubispora* Ellis & Holw. (Ellis & Holway, 1885) from the type locality in Iowa. Seaver (1910) transferred *H. cubispora* to his new genus *Chromocreopsis* as the type species, and reported two additional collections from Jamaica. It has been reported once from Java (Penzig & Saccardo, 1897), Kentucky (Kauffman, 1917), Smoky Mountains National Park (Linder, 1941), Gabon (Candoussau, 1981), and Quebec (McNeil, 1983). Corlett (1985) re-evaluated *Chromocreopsis cubispora* and considered this species and *Thuemenella javanica* O. Penzig & Sacc. to be conspecific. Since the name *Thuemenella* has priority, Corlett accepted Boedijn's combination *Thuemenella cubispora* (Ellis & Holw.) Boedijn. In addition, Rogers (1981) examined the two known collections of *Sarcoxylon deightonii* Petrak, both from Sierra Leone, and found them to be identical with *T. cubispora*. Samuels (1989) determined that *T. cubispora* has a xylariaceous anamorph, and proposes placing the genus in the Xylariaceae.

Wisconsin collections: Ozaukee Co., UW-Milwaukee Field Station, 28 VIII 1987, J. Steinke and A. Parker, 6 IX 1987, A. Parker; Washington Co., Pike Lake State Park, 7 X 1989, J. Steinke; Waukesha Co., Norman Chester Scientific Area, 17 IX 1983, A. Parker. Specimens deposited at BPI, DAOM, FH, and NY.

ACKNOWLEDGEMENTS

The author is indebted to Dr. Clark T. Rogerson for reviewing the manuscript and for his invaluable help with numerous questions. I thank Drs. Michael Corlett and Amy Rossman for making certain identifications, and Diana Parker and John Steinke for their enthusiastic help in collecting. Support for travel to the Aldo Leopold Memorial Reserve was provided in a grant from the Sand County Foundation.

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TYPE STUDIES IN THE POLYPORACEAE - 22. SPECIES DESCRIBED BY C.G. LLOYD IN **POLYPORUS**

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ABSTRACT. 170 species described by C.G. Lloyd in **Polyporus** have been reviewed and the type specimens examined. 119 names are synonyms of existing names, 26 are accepted, 15 names are illegitimate being homonyms of older names, the types for 9 names are sterile and one type is lost. 9 species are described, and the following new combinations are proposed: Polyporus moluccensis (Mont.) Ryv., Microporellus chocolatus (Lloyd) Ryv.,Amauroderma conicum (Lloyd) Ryv.,Spongipellis cretaceus (Lloyd) Ryv.,Microporellus inusitatus (Lloyd) Ryv.,Antrodiella murrillii (Lloyd) Ryv.,Perenniporia neofulva (Lloyd) Ryv.,Pyrrhoderma scaura (Lloyd) Ryv.,Perenniporia subcretacea (Lloyd) Ryv., Amauroderma unilaterum (Lloyd) Ryv. Phellinus kanehirae (Yasuda) Ryv.

KEYWORDS. Basidiomycetes, Polyporaceae, C.G. Lloyd.

INTRODUCTION. This is a continuation of a series of papers treating the species C. G. Lloyd described in Polyporaceae s. lato. The reader is referred to Ryvarden 1989 for a general introduction to the series. As in the previous part I have followed the Index of Stevenson and Cash (1936) which lists all his new names and combinations. In the Index there are references to the place of publication, Lloyd's collection number and other pertinent data concerning the types. To save space, this information is not repeated here although the country from where the species was described is given after an abbreviated reference to where the name was published. L.M.W. means Lloyd Mycological Writings and the next digit refers to the volume of the bound version followed with a reference to the pertinent page and year.

In this paper the species are treated in the same way as in the Stevenson and Cash Index, i.e. alphabetically according to specific epithet. The names of the accepted species have been written in bold face indicating the taxonomic disposition according to the authors opiion.

The remaining species described in Polystictus and Trametes will be treated similarly in a third and final part.

When a species is accepted taxonomically, it is cited in the appropriate genus with a reference to a recent description, or the species is described if no modern description seems to exist.

POLYPORUS

acervatus, P. L.M.W. 6:1006, 1920. Singapore.
= *Polyporus grammocephalus* Berk.
aduncus, P. L.M.W. 4:56, 1915. USA.
= *Inonotus circinatus* (Fr.) Gilbn.
albertinii, P. L.M.W. 3:160, 1912.Australia.
= **Inonotus albertinii** (Lloyd) Buchanan & Ryv.
For a description see Cunningham 1965:263 as *Inonotus hispidans* G.H. Cunn.
albo-fuscus, P. L.M.W. 7:1318, 1924. Australia.
= *Piptoporus portentosus* (Berk.) G.H. Cunn.
albojavensis, P. L.M.W. 7:1246, 1924. Indonesia.
= *Antrodia similis* (Bres.) Ryv.
albospongia, P. L.M.W. 5:L 68:8, 1918. Brazil.
= The type is lost.
amesii, P. L.M.W. 4:309, 1915. USA.
= *Bjerkandera adusta* (Fr.) Karst.
angolensis, P. L.M.W. 6:997, 1924. Angola.
= *Piptoporus soloniensis* (Dub.:Fr.) Pilát.
arensobasus, P. L.M.W. 6:919, 1920. South Africa.
= *Amauroderma* sp. Reid (1974: 22) has given a modern description of the isotype in herb. PRE which is in the same bad condition as the holotype in herb Lloyd. As no spores are present that with certainty can be connected to the type-collection, its true identity will be unknown.
areosus, P. L.M.W. 7:1155, 1922. Philippine Islands.
= **Polyporus moluccensis** (Mont.) Ryv. comb. nov. Basionym:
Favolus moluccensis Mont. Ann. Sci. Nat. Ser. 2, vol. 20: 365, 1843. = *Favolus spatulatus* (Jungh.) Lév. non *Polyporus spatulatus* (Hook.) Fr. Epicr. mycol. 1838. Corner (1984) proposed to merge *Favolus* Fr. 1828 with *Polyporus* s. str. an idea I support today. My previous concept as stated in Ryvarden & Johansen 1980, was partly based on the erroneous assumption that the generative hyphae were simple septate. Examinations of fresh specimens has demonstrated that clamps are present and this make it impossible to keep *Favolus* as a separate genus. Junghuhn's name *Laschia spatulatus* of 1838 is the oldest name for the taxon discussed here. Unfortunately it cannot be transferred to *Polyporus* as suggested by Corner (op. cit. p. 67) because the name is preoccupied as indicated above. Montagne named the species again in 1843 and his name is therefore used in *Polyporus.*
armadillus, P. L.M.W. 6:1062, 1921. Philippine Islands.
=*Ganoderma* sp. The species belongs in the section characterized by a light-coloured context and a laccate upper surface. The whole group of species has to be revised before Lloyd's name can be evaluated.
ater, P. L.M.W. 6:1003, 1920. Singapore.
= *Amauroderma rugosum* (Nees: Fr.) Torrend
atrohispidus, P. L.M.W. 5:823, 1919. Australia.
= *Tyromyces pelliculosus* (Berk.) G.H. Cunn. as already indicated by Cunningham (1965: 124).
aureofulvus, P. L.M.W. 7:1108, 1922. New Zealand.
= *Rigidoporus laetus* (Cke) Buchanan & Ryv.
aureus, P. L.M.W. 5:66, 1917. Chile.
= Illegitimate name, non *P. aureus* Berk. 1843.
The type of this name is a specimen of *Rigidoporus laetus* (Cke.) Buchanan & Ryv.

ballouii, P. L.M.W. 4:58, 1915. USA.
= Abortiporus biennis (Bull.:Fr.) Sing.
bathei, P. L.M.W. 4: L43:2, 1912. Madagascar.
= Amauroderma preussii (Henn.) Stey.
beardsleii, P. L.M.W. 7:1330, 1924. USA.
= Laetiporus percicinus (Berk. & Curt.) Gilbn.
bibulosus, P. L.M.W. 7:1329, 1924. Malaysia.
= **Phylloporia bibulosa** (Lloyd) Ryv. For a description, see Ryvarden & Johansen 1980:231.
biogilvus, P. L.M.W. 6:943, 1920. Angola.
= Coriolopsis sanguinaria (Kl.) Teng.
brockesii, P. L.M.W. 4:42, 1912. Brazil.
= Amauroderma calcigenum (Berk.) Torr. as stated by Furtado (1981:31).
brunneo-maculatus, P. L.M.W. 3:133, 1912. Singapore.
= Coriolopsis sanguinaria (Kl.) Teng.
burkillii, P. L.M.W. 6:1061, 1921. Singapore.
= Polyporus dictyopus Mont.
cantharellus, P. L.M.W. 4:54, 1915. Japan.
= **Albatrellus cantharellus** (Lloyd) Pouz.
For a description, see Pouzar 1975.
capensis, P. L.M.W. 5:63, 1916.South Africa.
= Ganoderma lucidum (Curt.:Fr.) Karst. s. lato.
Reid (1975:53) is of the opinion that it represents a taxon of its own and has given a detailed description and transferred the species as **Ganoderma capensis** (Lloyd) Reid.
chocolatus, P. L.M.W.7: 1194, 1923. India. Fig. 1.
= **Microporellus chocolatus** (Lloyd) Ryv. comb. nov.
Basionym: Polyporus chocolatus Lloyd, Lloyd Mycol. Writ. 7:1194, 1923,
Basidiocarp stipitate , pileus up to 10 cm wide with a short thick stipe, probably fleshy when fresh, friable and light of weight when dry, upper surface glabrous, smooth, pale buff to wood-coloured, pore surface pale brown, pores 4-5 per mm, but seemingly slightly shrunken under drying, tubes fragile, resinous fragile and brown, strongly contrasting the context which is homogeneous, cream, dense and somewhat cheesy in consistency.
Hyphal system dimitic, generative hyphae with clamps, difficult to observe in the dried type, hyaline 2-5 um wide, some gloeopleurous hyphae also present, negative in Melzer's reagent, yellowish and filled with granular contents, binding hyphae of the Bovista type present, thick-walled with solid apices, hyaline, up to 10 um wide in the central stem, cystidia and basidia not seen, basidiospores ovate, slightly thick-walled and pale yellow, negative in Melzer's solution, 5-7 x 4-5 um. There is no information about the substrata.
The generic assignment of this species is difficult to decide. The binding hyphae remind much of Polyporus s. str. but thick-walled and yellow spores are unknown in that genus. Microporellus has similar stipitate basidiocarps and spores, but usually the basidiocarps are more slender and the spores are hyaline.and skeletal hyphae are present without any presence of gloeopleurous hyphae.

conchatus, P. L.M.W. 5:700, 1917. South Africa.
= Illegitimate name non, P. conchatus Pers.: Fr. 1821.
The species was transferred to Antrodia by Reid (1974: 222) without being aware that he made an illegitimate new combination. What Reid technically did was to coin a nomen novum, hence the species should be cited: Antrodia conchata Lloyd ex Reid.
= **Antrodia conchata** (Lloyd) Reid. For a description, see Reid (op. cit.).

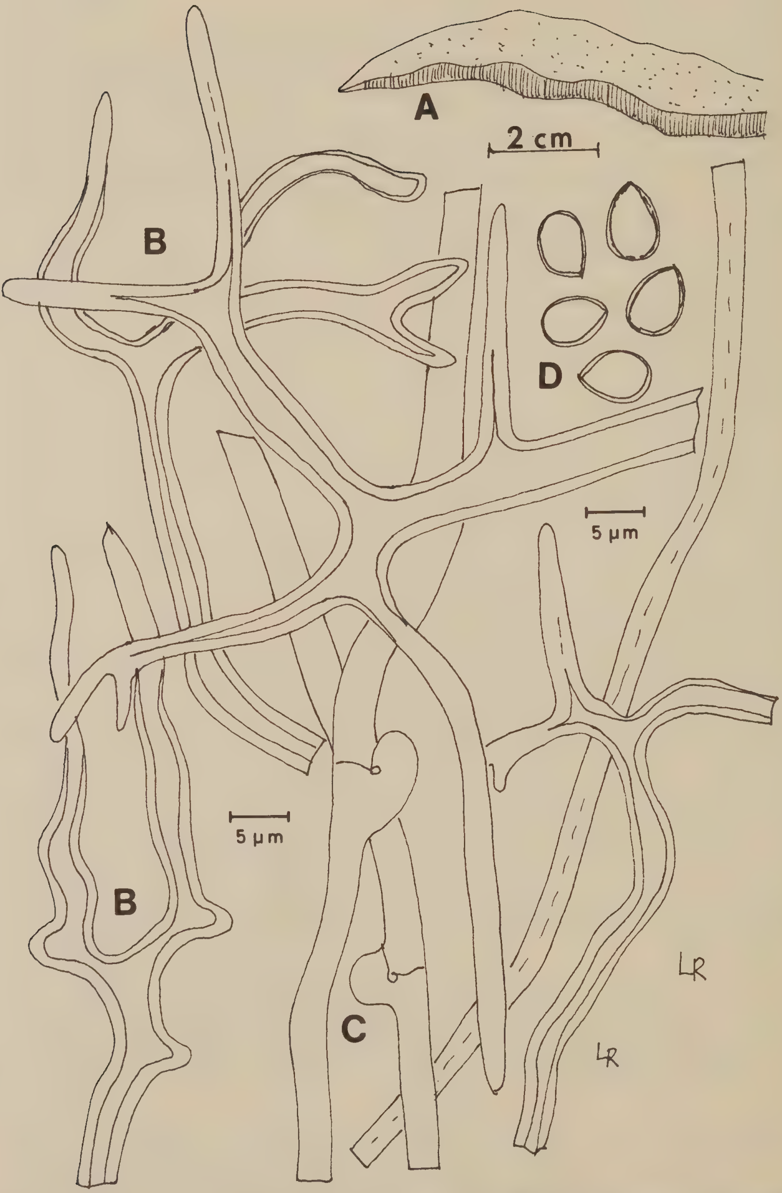
A
2 cm
B
D
5 µm
5 µm
B
C
LR
LR

Fig. 1. Microporellus chocolatus A) section of basidiocarp, B) vegetative hyphae, C) generative hyphae, D) spores. From the lectotype.

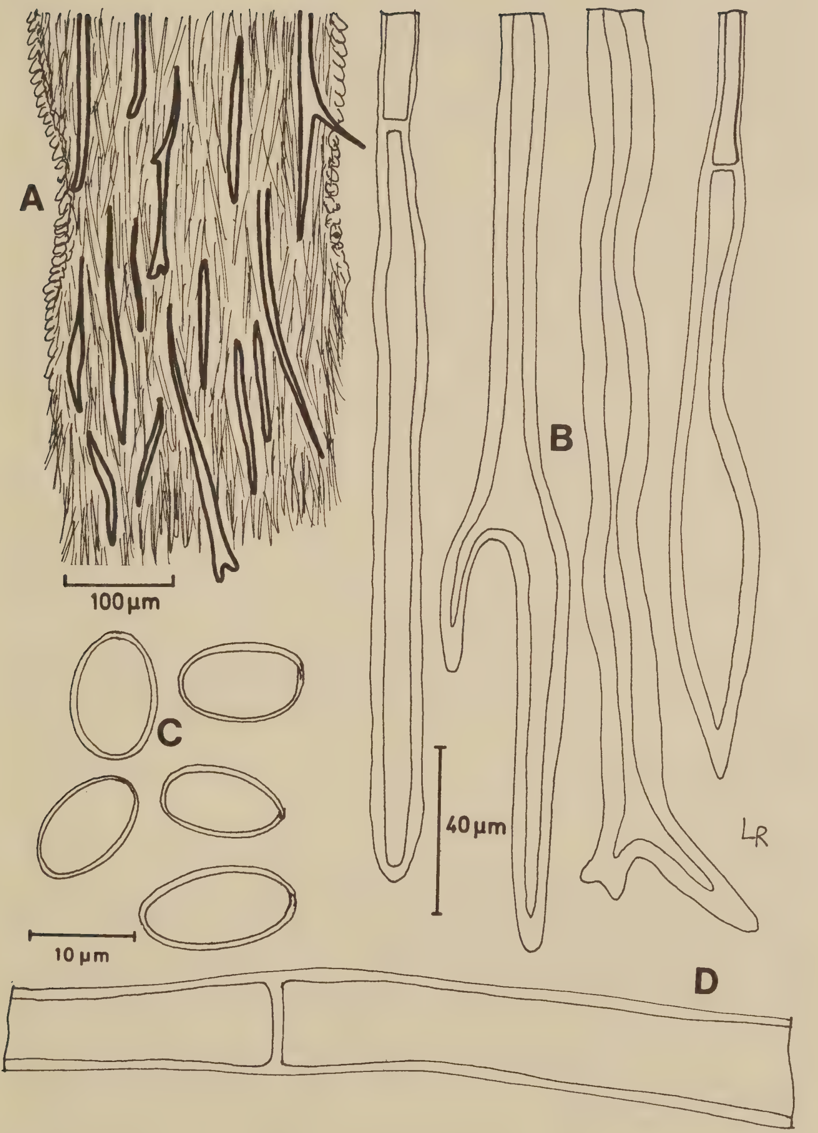
A
100 µm
B
40 µm
LR
C
10 µm
D

Fig. 2. Inonotus duostratosus A) section through dissepiments, B) setal hyphae, C) spores, D) generative hypha. From the lectotype.

conicus, P. L.M.W. 4:48, 1913. Madagascar.
= **Amauroderma conicum** (Lloyd) Ryv. comb. nov. Basionym: Polyporus conicus Lloyd, Lloyd Mycol. Writ. 4:48, 1913. This is a prior name for A. expallens (Bres.) Furt. For a description, see Furtado (1981:46).
conjunctus, P. L.M.W. 5:812, 1918. West Africa.
= **Amauroderma conjunctum** (Lloyd) Torr. For a description, see Furtado 1981:38-40).
cornucopiae, P. L.M.W. 7:1316, 1924. Brazil.
= Polyporus udus Jungh.
costatus, P. L.M.W. 4:56, 1915. Philippine Islands.
= Amauroderma longipes (Lév.) Torr. as stated by Furtado (1981:56).
cretaceus, P. L.M.W. 4:302, 1915. Australia.
= **Spongipellis cretaceus** (Lloyd) Ryv. comb. nov. Basionym: Polyporus cretaceus Lloyd, Lloyd Mycol. Writ. 4:302, 1915.
Cunningham (1965:106) gave a detailed description and placed the species in Piptoporus which however is a dimitic species with Bovista-like binding hyphae. P. cretaceus has dropshaped thick-walled spores and a monomitic hyphal system with clamps on the generative hyphae. This corresponds exactly to the generic characters of Spongipellis, thus the combination proposed above.
cystidioides, P. L.M.W. 6:1002, 1920. Singapore.
= **Flaviporus cystidioides** (Lloyd) Corner. For a description, see Corner (1987:157).
deceptivus, P. L.M.W.7:1316, 1924. Malaysia.
= Coltriciella dependens (Berk. & Curt.) Murr.
dispansus, P. L.M.W. 3:192, 1912. Japan.
= **Albatrellus dispansus** (Lloyd) Canf. & Gilbn. For a description, see Gilbn. & Ryv.(1986:96).
dorsalis, P. L.M.W. 5:658, 1915. Brazil.
= **Ganoderma dorsale** (Lloyd) Rick. Brazil.
This is yet another species in the G. lucidum group. No purpose is served by giving a detailed description of this species here. It has to be reexamined when somebody starts the heroic task of trying to entangle the almost impenetrable mass of names in this genus.
dubiocochlear, P. L.M.W. 4:43, 1912. Madagascar.
= Ganoderma lucidum (Curt.:Fr.) Karst. s. lato.
dubiopansus, P. L.M.W. 3:125, 1912. Brazil.
= Amauroderma sprucei (Pat.) Torr.
duostratosus, P. L.M.W. 7:1317, 1924. Malaysia. Fig.2.
= **Inonotus duostratosus** (Lloyd) Buchanan & Ryv.
Basidiocarp solitary to imbricate, annual, dimidiate to laterally to eccentrically stipitate with a expanding stipe or base, pileus up to 8 cm wide, up to 15 mm at the base, upper surface fulvous, sienna to dark cinnamon, often zonate, first finely tomentose, by age becoming agglutinated and with a papery surface but no cortex present, margin wavy, undulate? entire to lobed, stipe short and expanding toward the pileus, up to 3 x 2 cm, tomentose, rusty brown, pore surface dark rusty brown, pores angular, thin-walled, 1-2 per mm, tubes up to 10 mm deep, light cinnamon on tube walls in fresh and properly dried specimens, context concolorous with upper surface, dense in lower part, looser and compressible in upper part, up to 6 mm thick.
Hyphal system monomitic, generative hyphae with simple septa in subhymenium, hyaline 2-5 µm wide, in trama and context 5-10 µm wide, yellow to rusty brown with thickened walls, sparingly branched.
Setal hyphae very abundant in the dissepiments, more scattered in context, dark brown, thick-walled to almost solid in parts, up to 150 µm long, 5-15 µm wide, sharply pointed, straight, rarely projecting into the pores, occasionally dichotomously forked in

the upper part.

Hymenial setae not seen, and apparently absent.

Basidia clavate, 2-4 sterigmate, 24-30 x 6-10 µm.

Basidiospores ellipsoid, to subcylindric, yellow to rusty brown and thick-walled, 9-12 x 7-9 µm. Known only from Malaysia.

The species is characteristic by its semistipitate basidiocarp, the numerous setal hyphae and the large spores.

duroporus, P. L.M.W. 6:1076, 1921. China.

= Ganoderma lucidum (Curt.:Fr.) Karst. s. lato.

euzonatus, P. L.M.W. 6:892, 1919. Bahamas.

= Coriolopsis fulvocinerea Murr.

farinosus, P. L.M.W. 4:337, 1915. Brazil.

= Illegitimate name, not P. farinosus Bref. 1889. Lloyd was also unaware that Rick already had published the same (and illegitimate) name based on the same type. Ricks illegitimate name was later changed to Polyporus rickianus Sacc. & Trott.

All these names are based on a small specimen of Trametes ectypus (Berk. & Curt.) Ryv.

Rajchenberg (1987: 559) has a detailed account of the publication and changes of these names.

farlowii, P. L.M.W. 4:363, 1915.(K) USA.

= **Inonotus farlowii** (Lloyd) Gilbn. For a description, see Gilbn. & Ryv. 1986:375.

fijii, P. L.M.W. 7:1112, 1922. Fiji.

= Coriolopsis asper (Jungh.) Teng.

fumoso-olivaceus, P. L.M.W. 5:69, 1919. Sri Lanka.

= Coriolopsis strumosa (Fr.) Ryv.

fuscatus, P. L.M.W. 6:942, 1920. Angola.

= Illegitimate name, a homonym of P. fuscatus Fr.:Fr. 1821.

The species was later renamed Amauroderma oblongisporum Furt.

fuscellus, P. L.M.W. 6:1044, 1921. Indonesia.

= Microporellus obovatus (Jungh.) Ryv.

fusco-dresdensis, P. L.M.W. 7:1112, 1922. Australia.

= Loweporus fuscoalbus (Pers.) Ryv.

fusco-mutans, P. L.M.W. 7:1158, 1922. USA.

= Tyromyces fissilis (Berk. & Curt.) Donk, as already noted by Lowe in Lloyd's herbarium.

gilvo-rigidus, P. L.M.W. 7:1334, 1925. New Zealand.

= Cyclomyces tabacinus (Mont.) Pat.

globocephalus, P. L.M.W. 5:652, 1917. Brazil.

= The type consists of a sterile fruitbody without pores.

The hyphae are all simple septate and for all I know it may represent an early stage of an anamorph.

gossweilerii, P. L.M.W. 5:67, 1918. Angola.

= Ganoderma lucidum (W.Curt.:Fr.) Karst. s. lato.

grantii, P. L.M.W. 5:763, 1918. USA.

= Oligoporus guttulatus (Peck) Gilbn. & Ryv.

granulatus, P. L.M.W. 7:1113, 1922. Zaire.

= Trametes cingulata Berk.

greenii, P. L.M.W. 5:843, 1919.Japan.

= Coltricia montagnei (Fr.) Murr.

griseo-durus, P. L.M.W. 5:68, 1918. Japan.

= Fomitopsis nivosa (Berk.) Gilbn. & Ryv.

guhae, P. L.M.W. 7:1147, 1922. India.

= Rigidoporus fuscolineatus (Pers.) Ryv.

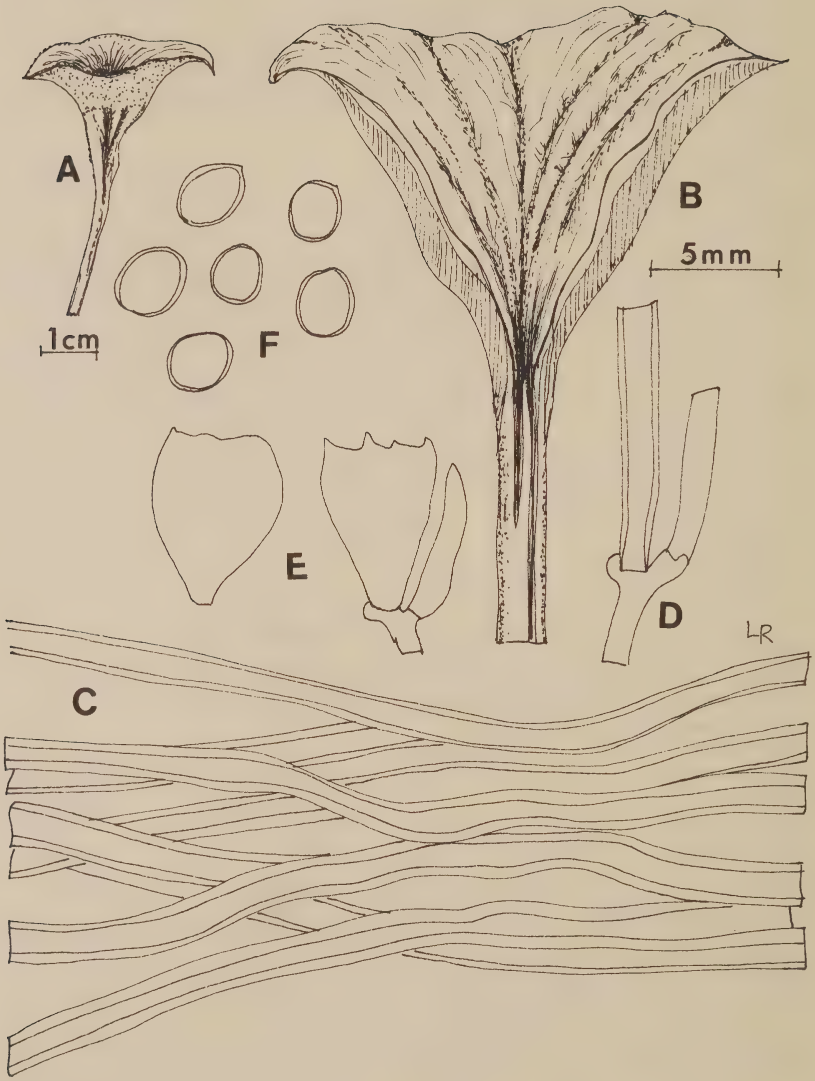

Fig. 3. Microporellus inusitatus A) basidiocarp, B) section through basidiocarp, C) skeletal hyphae, D) generative hyphae with the start of a skeletal hypha, E) basidia, F) spores. From the lectotype.

haedinus, P. L.M.W. 7:1194, 1923.
= Illegitimate name as a homonym of P. haedinus Berk. 1856.
The type of Lloyd's illegitimate name is a small specimen of Polyporus udus Jungh.
henningsii, P. L.M.W. 3:105, 1912.
= Illegitimate name as a homonym of P. henningsii Bres. 1891.
There is no specimen under this name in the Lloyd herbarium.
hiascens, P. L.M.W. 7:1109, 1922. Brazil.
= Aporpium substuppeus (Berk. & Curt.) Rajch.
hookeri, P. L.M.W.4:348, 1915.(K) India.
= Phellinus gilvus (Schw.) Pat.
imporcatus, P. L.M.W. 5:68, 1918. Indonesia.
= Phlebia sp. A world wide study of this genus is necessary before the status of Lloyd's species can be settled.
infulgens, P. L.M.W. 5:656, 1917. Brazil.
= Ganoderma coffeatum (Berk.) Furtado.
inopinus, P. L.M.W. 5:802, 1918. Brazil.
= Amauroderma camerarium (Berk.) Furtado, as noted by Furtado (1981:35).
intactilis, P. L.M.W. 6:887, 1919. West Africa.
= Phellinus senex (Nees & Mont.) Imazeki.
inusitatus, P. L.M.W. 7:1334, 1925. Malaysia. Fig.3.
= **Microporellus inusitatus** (Lloyd) Ryv. comb. nov.
Basionym: Polyporus inusitatus Lloyd, Lloyd Mycol. Writ. 7:1334, 1925.
Basidiocarp annual, centrally stipitate, funnel-shaped, up to 8 cm high, pileus circular, strongly centrally depressed, up to 5 cm in diameter, rather brittle when dry, upper surface glabrous, distinctly radially striate or veined, pale to dark brown, stipe concolorous, pore surface white, pores angular to elongated and sinuous towards the stipe, 2-3 per mm, tubes up 4 mm deep concolorous, context white to pale cream, dense, approximately 1 mm thick at the central parts of the basidiocarp.
Hyphal system dimitic, generative hyphae hyaline, thin-walled and with clamps at the septa, 2.5-4 um wide, skeletal hyphae abundant, thick-walled but with a wide lumen, straight to somewhat flexuous, distinctly dextrinoid, 2.5-5 um wide, cystidia not seen, basidia broadly clavate with 4 sterigmata 14-18 x 5-10 um, basidiospores globose, slightly thick-walled, dextrinoid, 5-6 um in diameter, probably on dead hardwood, but no information is available on the substratum.
It is a matter of opinion whether this species best is placed in Microporellus or Perenniporia. Both genera have dextrinoid skeletal hyphae and slightly thick-walled dextrinoid spores. However, in the type species of the former, ventricose cystidia are present as is the case in some other species in the genus, although there are also very similar species where no cystidia can be observed. In Perenniporia most species are resupinate (as the type species P. medulla-panis) or pileate although a few laterally stipitate species are known, such as P. stipitata. The centrally rather thin basidiocarp of P. inusitatus seems to indicate that Microporellus is the most natural genus as this type of basidiocarp is a generic character in this genus. For a more detailed description of the type species of the genus and its cultural characters, see David & Rajchenberg 1985
iowensis, P. L.M.W. 7:1363, 1925. USA.
= Tyromyces galactinus (Berk.) Lowe.
itoi, P. L.M.W. 7:1274, 1924. Japan.
= Trametes suaveolens L.:Fr.
junctus, P. L.M.W. 7:1317, 1924. Japan.
= Perenniporia ochroleuca (Berk.) Ryv.

juxtarugosus, P. L.M.W. 6:1096, 1921. Japan.
= Amauroderma subrugosum (Bres. & Pat.) Torr. as already stated by Furtado 1981:91.
krakatani, P. L.M.W. 7:1242, 1924. Indonesia.
= Microporellus obovatus (Jungh.) Ryv.
labis, P. L.M.W. 7:1191, 1923. Sarawak.
= Perenniporia detrita (Berk.) Ryv.
lateritius, P. L.M.W. 5:67, 1918. Australia.
= Illegitimate name, a homonym of P.lateritius Cke 1880.
maculatissimus, P. L.M.W. 7:1113, 1922. Australia.
= Polyporus udus Jungh.
madagascarensis, P. L.M.W. 4:48, 1915. Madagascar.
= Amylosporus campbellii (Berk.) Ryv.
magnoporus, P. L.M.W. 7:1111, 1922. Australia.
= Polyporus fuscolineatus Berk. & Br. as already stated by Cunningham 1965: 135.
magnovarius, P. L.M.W. 7:1192, 1923. Brazil.
= Polyporus varius Fr.
malnominus, P. L.M.W. 3:187, 1912. Mexico.
=Polyporus dictyopus Mont.
manilaensis, P. L.M.W. 5:68, 1918. Philippine Islands.
= Trametes radiatorugosa (Bres.) Ryv.
marucuccianus, P. L.M.W. 4:348, 1915.Italy.
= Phellinus torulosus (Pers.) Bourd. & Galz.
medullae, P. L.M.W. 7:1330, 1924. China.
= Piptoporus soloniensis (Dub.:Fr.) Pilát.
melanoporus, P. L.M.W. 6:1087, 1921. Philippine Islands.
= Illegitimate name, a homonym of Polyporus melanoporus Mont. 1842.
The type of Lloyd illegitimate name represents, however, the same species, viz. Nigrofomes melanoporus (Mont.) Murr.
mesotalpae, P. L.M.W. 4:564, 1916. Sri Lanka.
= Laetiporus percicinus (Berk. & Curt.) Gilbn.
metallicus, P. L.M.W. 6:1099, 1921. USA.
= Ganoderma tsugae Murr.
mikadoi, P. L.M.W. 4:43, 1912. Japan.
= **Inonotus mikadoi** (Lloyd) Bond. For a description, see Pegler 1964: 190.
mikawai, P. L.M.W. 4:54, 1915. Japan.
= Polyporus cfr. varius Fr.
Only a single, small basidiocarp is known and it reminds about an immature basidiocarp of P. varius with the same leather-coloured upper surface although the dark base is absent and the pores are a bit more angular and thin-walled than seen in European specimens. The spores are 7.5-9 x 2-3 um, slightly longer also than in European specimens. A taxonomic revisions of the East Asian species of Polyporus s. str. is needed before a conclusion can be made on its taxonomic status.
minuto-durus, P. L.M.W. 7:1109, 1922. Ecuador.
= Rigidoporus microporus (Sw.:Fr.) Overeem.
mollicarnosus, P. L.M.W. 4:60, 1915. South Africa.
= Navisporus floccosus (Bres.) Ryv. There is a description of the type specimen in Reid 1974: 224.
molliculus, P. L.M.W. 6:940, 1920. Sri Lanka.
= Oligoporus cfr. tephroleucus (Fr.) Gilbn. & Ryv.
Microscopically there are no differences between the type specimen and specimens from the boreal zone although the type of rot is not known for P. molliculus.

mollitextus, P. L.M.W. 6:880, 1919. West Africa.
= Amylosporus campbellii (Berk.) Ryv.
multilobatus, P. L.M.W. 7:1146, 1922. Bahamas.
= "Irpex" sp. of unknown identity.
multiplex,P.L.M.W. 3:152, 1912, Australia (K).
= Grifola colensoi (Berk.) Cunningh. as already indicated by Cunningham (1965:95).
multisetosus, P. L.M.W. 6:976, 1920. Australia.
= Phellinus setulosus (Lloyd) Imaz.
munzii, P. L.M.W. 7:1163, 1922, USA.
= **Inonotus munzii** (Lloyd) Gilbn. For a description, see Gilbertson & Ryvarden 1986:383.
murrillii, P. L.M.W. 5:857, 1919. Belize. Fig.4 A-C
= **Antrodiella murrillii** (Lloyd) Ryv. comb nov.
Basionym:Polyporus murrillii Lloyd, Lloyd Mycol. Writ. 5:857, 1919.
Basidiocarp laterally stipitate, pileus semicircular with a tapering base, about 3 x 3 cm and 5 mm thick, dense and hard, upper surface glabrous, dull, tan to leather coloured, azonate, slightly velvety soft toward the stipe, stipe about 1 cm long and 5 mm in diameter, concolorous with the pileus, pore surface in type pale brown, pores small and round, almost invisible to the naked eye, 6-8 per mm, tubes dense and cartilaginous, pale brown and distinctly darker than the context, 0.5-1.5 mm thick, context ochraceous to cream, distinctly duplex but without any dark zone, lower part dense and 2 mm thick, upper part looser, 1.5 mm thick.
Hyphal system dimitic, generative hyphae hyaline, thin- to distinctly thick-walled and with clamps at the septa, 2-5 um wide, skeletal hyphae hyaline, thick-walled to solid, negative in Melzers reagent, 3-5 um wide, cystidia and basidia not seen, basidiospores abundantly present, hyaline, oblong ellipsoid, 3-4 x 1.5-2 um. Presumably on dead hardwood.
Even if this is a distinctly laterally stipitate species, I have no doubt that Antrodiella is the correct genus for it. The dense cartilaginous consistency with small spores, the dimitic hyphal system and the small pores all point clearly towards this genus even if most species in the genus either have a resupinate to pileate, sessile basidiocarp.
neofulvus, P. L.M.W. 4:60, 1915. Brazil. Fig.4 D-F
= **Perenniporia neofulva** (Lloyd) Ryv. comb. nov.
Basionym: Polyporus neofulvus Lloyd, Lloyd Mycol. Writ. 4:60, 1915.
Basidiocarps annual, pileate, sessile,woody, semicircular, up to 2 cm wide and 1 cm thick at the base, upper surface cream to pale leather-coloured, glabrous, slightly sulcate and tuberculate, no cuticle, pore surface pale straw-coloured, pores angular and tiny 5-7 per mm, tubes concolorous, up to 8 mm deep, context dense, coriaceous, cream-coloured, homogeneous, 1-3 mm thick.
Hyphal system dimitic, generative hyphae hyaline and with clamps at the septa, 1-3 um in diameter, skeletals thick-walled to solid, sinuous and occasionally branched, 1-3 um wide in trama, wider and up to 5 um in the context,IKI-.
Cystidia and basidia not seen.
Basidiospores subglobose, thick-walled and weakly dextrinoid, 3-4 um in diameter.
Known only from the southern part of Brazil, Rio Grande do Sul.
This species comes close to P. micropora Ryv. which however is a thinner species with smaller pores and larger spores. The skeletal hyphae of P. neofulva are also wider, this is especially striking when sections from the context of the two species are compared.
niger, P. L.M.W. 6:881, 1919. Cameroon.
= Illegitimate name as a homonym of P. niger Berk. 1845.
The type of Lloyd's name is a specimen of Amauroderma subrugosum (Bres. & Pat.) Torr. according to Furtado (1981:91).

SEE ERRATA

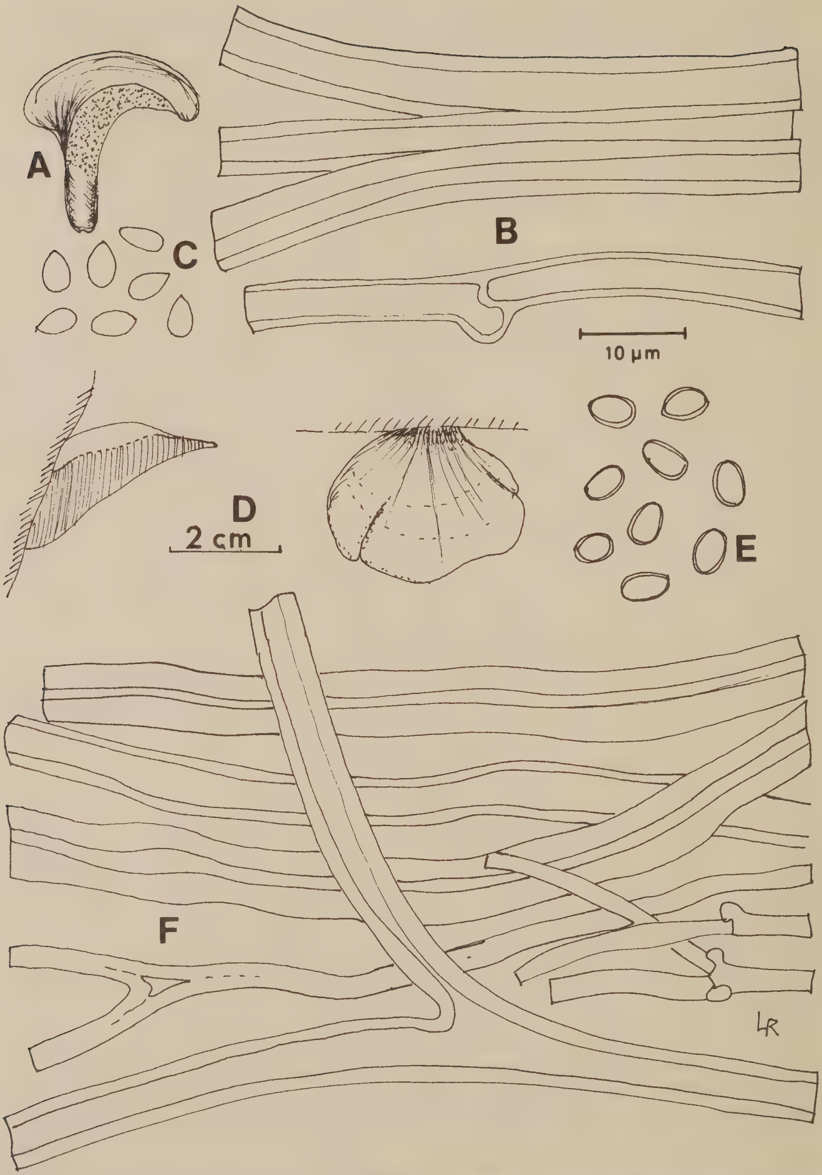

Fig. 4. Antrodiella murrillii A) basidiocarp, B) skeletal hyphae and generative hypha, C) spores. Perenniporia neofulva D) basidiocarp, E) spores, F) skeletal and generative hyphae. From the lectotype.

nigrocrustosus, P. L.M.W. 4:373, 1915. India.
= *Ganoderma* cfr. *amboniense* (Lam.) Bres.
nigrolucidus, P. L.M.W. 6:925, 1920. South Africa.
=**Ganoderma nigrolucidum** (Lloyd) Reid. For a description, see Reid (1974:224).
nigroporus, P. L.M.W. 7:1238, 1924. Philippine Islands.
= *Aurificaria poncei* (Lloyd) Reid.
nigro-rugosus, P. L.M.W. 7:1270, 1924. Philippine Islands.
= *Ischnoderma resinosum* (Fr.) Karst.
nongravis, P. L.M.W. 6:891, 1919. Sri Lanka.
= *Schizopora flavipora* (Cooke) Ryv.
obniger, P. L.M.W. 5:632, 1917. Australia.
= *Polyporus dictyopus* Mont.
orientalis, P. L.M.W. 3:193, 1912. Japan.
= *Coltricia vallata* (Berk.) Teng
oroniger, P. L.M.W. 6:1044, 1921. Philippine Islands.
= *Phellinus pectinatus* (Kl.) Quél.
pallido-sporus, P. L.M.W. 5:63, 1916. Brazil.
= *Amauroderma boleticeum* (Pat. & Gaill.) Torr.
papillatus, P. L.M.W. 4:567, 1916. Brazil.
= *Amauroderma schomburgkii* (Mont. & Berk.) Torrend as already indicated by Furtado (1981: 77).
peakensis, P. L.M.W. 6:933, 1920. USA.
= *Inonotus tomentosus* (Fr.) Teng.
pectunculus, P. L.M.W. 7:1315, 1924. South Africa.
= Illegitimate name as a homonym of *P. pectunculus* Lév. 1846. The type specimen of Lloyds illegitimate name is a specimen of *Trametes varians* Van der Byl.
pelles, P. L.M.W. 4:327, 1915. Australia.
= *Tyromyces pelliculosus* (Berk.) G.H. Cunningham as already indicated by Cunningham (1965:124).
perturbatus, P. L.M.W. 5:68, 1918. Brazil.
= *Ganoderma lucidum* (Curtis: Fr.) Karst. s. lato.
perversus, P. L.M.W. 3:136, 1912. Philippine Islands.
= *Polyporus grammocephalus* Berk.
poncei, P. L.M.W. 7:1191, 1923.Philippine Islands.
= **Aurificaria poncei** (Lloyd) Reid.
This species is similar to *A. indica* (Mass.) Reid in all characters except for the spores which are 4-5.5 x 3.5-4.5 um in *A. poncei* and 5-7 x 4.5-6 um in *A. indica*. For a description of the latter species and an illustration of spores from both species, see Ryvarden & Johansen 1980: 100.
profissilis, P. L.M.W. 5:810, 1918. Japan.
= *Spongipellis delectans* (Peck) Murr.
propinquus, P. L.M.W. 7:1109, 1922. Bahamas.
= *Amylosporus campbellii* (Berk.) Ryv.
proprius, P. L.M.W.7:1328, 1924. New Zealand (K).
= *Bondarzewia berkeleyi* (Fr.) Bond. & Sing.
pseudofruticum, P. L.M.W. 4:54, 1915. Brazil.
= *Phylloporia chrysita* (Berk.) Ryv.
pseudogilvus, P. L.M.W. 6:940, 1920. Cuba.
= *Phellinus gilvus* (Schw.) Pat.
pubertatis, P. L.M.W. 4:358, 1915. Japan.
= *Loweporus roseoalbus* (Jungh.) Ryv.

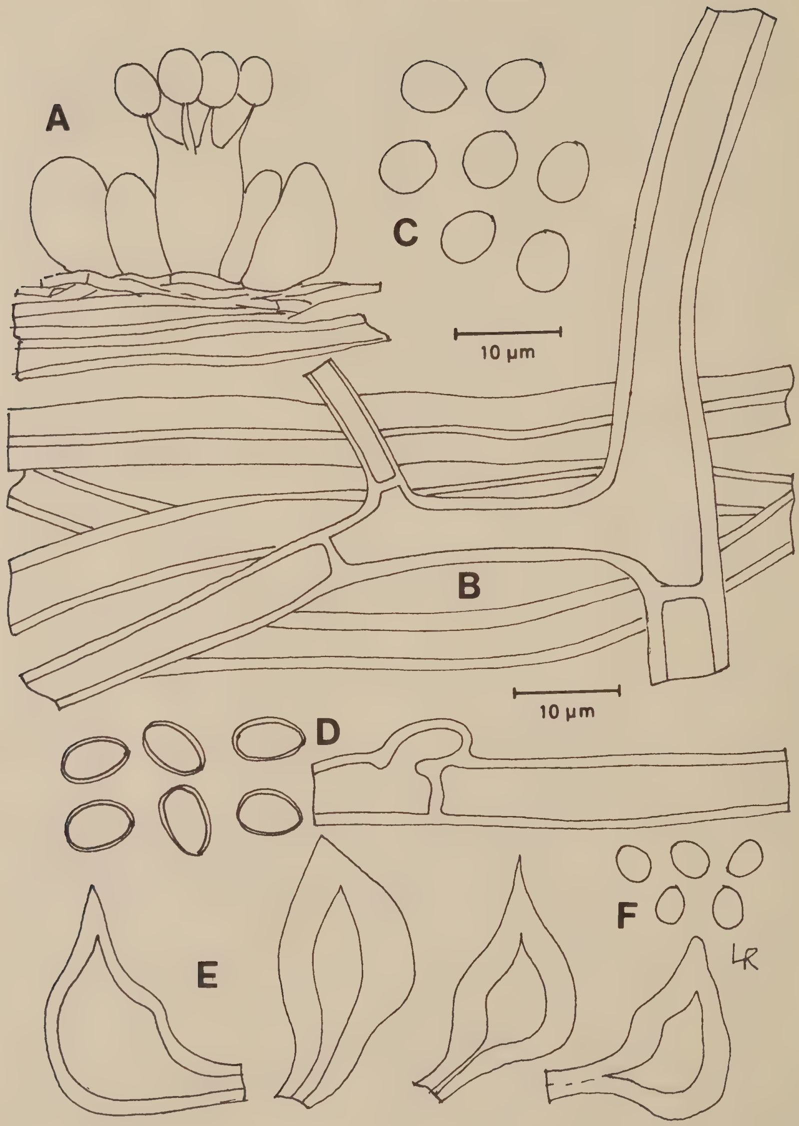

Fig. 5. Pyrrhoderma scaura A) part of hymenium, B) generative hyphae, C) spores, Perenniporia subcretacea d) spores and generative hypha, Phellinus kanehirae E) setae, F) spores. From the lectotypes.

radula, P. L.M.W. 5:67, 1918. Bahamas.
= Illegitimate name as a homonym of Polyporus radula Fr. 1821. The type of the name is a specimen of Fomitopsis palustris (Berk. & Curt.) Gilbn. & Ryv.
retro-ater, P. L.M.W. 7:1112, 1922. Malaysia.
= Coriolopsis sanguinaria (Kl.) Teng.
rosea-brunnea, P. L.M.W. 7:1290, 1924. China.
= Phylloporia chrysita (Berk.) Ryv.
rosettus, P. L.M.W. 5:601, 1916. Australia.
= Tyromyces campylus (Berk.) Ryv.
ruforugosus, P. L.M.W. 7:1331, 1924. Australia.
= Trametes sp.The type is sterile and seems to be treated with some sort of chemical for disinfection. More collections close to Hobart in Tasmania (the type locality) are needed before a conclusion can be drawn to its true identity.
rugatus, P. L.M.W. 7:1110, 1922. Australia.
= Amauroderma rude (Berk.) Torrend as pointed out by Cunningham (1965:142).
rugiceps, P. L.M.W. 7:1329, 1924. Australia.
= Amauroderma rude (Berk.) Torrend as pointed out by Cunningham (1965:142).
rugosissimus, P. L.M.W. 4:48, 1913. Madagascar.
= Amauroderma preussii (Henn.) Stey.
rugoso-sporus, P. L.M.W. 4:339, 1915. Zaire.
= Coriolopsis asper (Jungh.) Teng.
rusticus, P. L.M.W. 5:751, 1918. South Africa.
= Coriolopsis floccosa (Jungh.) Ryv.
saitoi, P.L.M.W. 7:1269, 1924. Japan.
= Polyporus ciliatus Fr.
salebrosus, P. L.M.W. 4:42, 1912.Zaire.
= Amauroderma preussii (Henn.) Stey.
salmonicolor, P. L.M.W. 7:1360, 1925. USA.
= Illegitimate name as homonym of P. salmonicolor Berk. & Curt. 1849. The type of Lloyd's illegitimate name is a small specimen of Hapalopilus nidulans (Fr.) Karst.
sambuceus, P. L.M.W. 4:60, 1915. Japan.
= Piptoporus soloniensis (Dub.:Fr.) Pil.
sandakanii, P. L.M.W. 7:1145, 1924. Sarawak.
= Amauroderma rugosum (Blume & Nees : Fr.) Torrend.
scaurus, P. L.M.W. 4:53, 1914. Japan. Fig.5 A-C.
= **Pyrrhoderma scaura** (Lloyd) Ryv. comb. nov.
Basionym: Polyporus scaurus Lloyd, Lloyd Mycol. Writ. 4:53, 1914.
Basidiocarp annual, pileate, dimidiate to fan-shaped or semistipitate, up to 10 cm wide and long, to 8 mm thick at the base, dense and woody when dry, upper surface first yellowish brown, velutinate, dull and soft, later becoming more smooth, semi-glossy and umber brown, sulcate and tuberculate to undulating and when dry with radial furrows, in section with a distinct dark brown zone which by age becomes almost black, the upper part about 1 mm thick, pore surface yellowish brown to umber, pores small, hardly visible to the naked eye, 6-7 per mm, tubes concolorous, up to 3 mm deep, context dense, duplex, the lower part yellowish brown and with a radial structure, 3-7 mm thick, separated from the upper, thinner part by a thin dark brown to black zone, upper part about 1 mm thick and more rusty brown than the context proper.
Hyphal system monomitic or semi-dimitic, generative hyphae with simple septa, in the subhymenium hyaline, thin-walled and easily collapsed, 2-3 um, in the trama and context the hyphae are yellow to rusty brown, thick-walled to almost solid, 3-9 um wide, extremely sparingly branched, but with simple septa at the branching, setae not present, basidia barrel shaped with 4 sterigmata and a simple septum at the base lo-

15 x 7-10 um, basidiospores globose, thin-walled, hyaline, IKI-, 5-6 um in diameter. Causes a white rot in hardwoods. Known from Japan and China.

There is a coloured drawing in Imazeki & Hongo 1989, plate 127 and a brilliant colour-picture in Imazeki, Otani & Hongo 1988:492.

The hyphal system, as indicated above, is not so easy to interpret in this species. Personally I feel it can be defended to call it monomitic even if there are long, unbranched segments up to 300 um without a single septum. Such segments will easily in microscopic preparations be taken as skeletal hyphae and only prolonged examination of numerous hyphae will reveal the very scarce septa. The hyphae do not change character at the septa, which normally is the case when a generative hypha changes into a skeletal hypha, for example as seen in Phellinus.

The species is placed in Onnia in Japanese floras such as those cited above and in Ito 1955. This genus is typified by Polyporus circinatus Fr. a species with numerous large hooked setae and a distinctly monomitic hyphal system. It is the duplex consistency of this species and its general yellowish to rusty brown colour which are the reasons for also including P. scaurus in this genus.

Pyrrhoderma Imazeki, typified by Polyporus sendaiensis Yasuda, has on the other hand almost exactly the same characters as found in P. scaurus. For a description of Pyrrhoderma and its two species, see Imazeki 1966. P. sendaiensis is a stipitate species with a distinct glabrous greyish crust, but microscopically it is almost identical with P. scaurus except that the spores are slightly larger and slightly more subglobose of shape. To me it is very clear that P.scaurus should be placed here even so more as it has a strongly contracted base coming very close to a short lateral stipe. In the latter the dark blackish zone remains under a dense, thin cover of hyphae while in P. sendaiense is exposed as a greyish cuticle.

The position of Pyrrhoderma is probably in Hymenochaetaceae because of brown simple septate hyphae, black reaction of the context with KOH (xanthochroic reaction), a white rot and spores of a shape that is widespread in the family.

semibilanti, P. L.M.W. 7:1223, 1923.Malaysia.

= Microporellus clemensiae (Murr.) Ryv.

semistipitatus, P. L.M.W. 7:1271, 1924. USA.

= **Perenniporia semistipitata** (Lloyd) Gilbn.& Ryv. For a description, see Gilbertson & Ryvarden 1987:530.

sepia, P. L.M.W. 6:1045, 1920. Singapore.

= The type is old and weathered and no spores nor generative hyphae could be found. The basidiocarp consists of non-dextrinoid skeletal hyphae only. Its identity is unknown to me.

simulans, P. L.M.W. 7:1259, 1924. Uganda.

= Illegitimate name as a homonym of P. simulans Blonski 1889.

The type of Lloyd's illegitimate name is a Ganoderma sp.

sinensis, P. L.M.W. 7:1192, 1923. China.

= Illegitimate name as a homonym of P. sinensis Fr. 1821.

The type of Lloyd's illegitimate name is a specimen of **Phellinus kanehirae** (Yasuda) Ryv, comb. nov. Fig. 5 E-F.

Basionym: Polyporus kanehirae Yasuda Bot. Mag. Tokyo 35:205, 1921.

Basidiocarp pileate, woody, perennial, semi-circular to dimidiate, up to 7 cm wide and 1 cm thick, upper surface zonate, tomentose to scrupose, dark brown, pore surface concolorous, pores round and entire, 5-6 per mm, tubes chestnut to dark rusty brown, 2-4 mm deep, context dense,

rusty brown with a thin black line below the upper tomentum.

Hyphal system dimitic, generative hyphae delicately thin-walled, hyaline 2-3 um wide and with simple septa, difficult to observe, skeletal hyphae thick-walled to solid, rusty brown, unbranched, 3-5 um wide, basidia not seen, setae scattered, ventricose, thick-walled, dark brown and pointed, 20-28 x 9-12, a few with a more elongated basal part, spores abundant, subglobose, golden brown, 3.5-4 x 2.5-3 um. On dead hardwoods, known from Japan and China.

The species is undoubtedly close to the group of species around Phellinus pectinatus (Kl.) Quél. but easily separated by the small ventricose setae.

Imazeki (in Imazeki & Hongo 1969:157) with a coloured drawing transferred the species to Inonotus, but the hyphal system which I distinctly interpret as dimitic, and the small spores seems to indicate that Phellinus is a more natural genus. The species was not included in Imazeki & Hongo 1989.

smaragdinus, P. L.M.W. 5:818, 1919. USA.
= Tyromyces fumidiceps Atk.
strigoso-albus, P. L.M.W. 7:1329, 1924. Australia.
= Tyromyces pelliculosus (Berk.) Cunningh.
suaderis, P. L.M.W. 5:859, 1919. Australia.
= Australoporus tasmanicus (Berk.) Buchanan & Ryv.
subcretaceus, P. L.M.W. 7:1331, 1924. Fig. 5 D.
Australia, Tasmania, Hobart.
= **Perenniporia subcretacea** (Lloyd) Ryv. comb. nov.
Basionym: Polyporus subcretaceus Lloyd, Lloyd Mycol. Writ. 7:1331, 1924.

Basidiocarp annual, pileate, applanate, dimidiate, semicircular to fanshaped, approximately 5 cm wide and long, up to 2 cm thick at the base, upper surface black at the base with a thin cuticle becoming pale brown at margin, smooth to finely scrupose towards the base, azonate, pore surface white to cream, pores angular, thin-walled, partly incised along the dissepiments, (1) 2-3 per mm, tubes concolorous, up to 1 cm deep, context white, fibrous to cottony and compressible, up to 1 cm thick at the base.

Hyphal system dimitic, generative hyphae wide , thick-walled, but with a wide lumen, 3-8 um wide with large scattered clamps, walls up to 2 um thick in the widest sections, skeletal hyphae narrower, thick-walled, negative in Melzer's reagent, 2-4 um wide, present both in context and trama, basidia and cystidia not seen, basidiospores abundantly present, ellipsoid to slightly truncate, thick-walled and dextrinoid, 5-6(7) x 4-5 um, on dead hardwood of unknown identity.

The dextrinoid thick-walled spores and the dimitic hyphal system place this species in Perenniporia. The closest relative seems to be P. clelandii (Lloyd) Ryv. which however has larger spores and smaller pores. It is also restricted to Australia as far as we know today.

Cunningham (1965:283) did notexamine the type and consequently did not include it in his keys and descriptions.

subhispidus, P. L.M.W. 7:1330, 1924. India.
= Inonotus hispidus (Bull.:Fr.) Karst.
subradiatus, P. L.M.W. 4:346, 1915. South Africa.
= Phellinus discipes (Berk.) Ryv.
superniger, P. L.M.W. 6:1038, 1921. Philippine Islands.
= Fomitopsis rhodophaea (Lév.) Imaz.
tokyoensis, P. L.M.W. 4:302, 1915. Japan.
= Oligoporus tephroleucus (Fr.) Gilbn. & Ryv.
torrendii, P. L.M.W. 4:54, 1915. Brazil.
= Amauroderma calcigenum (Berk.) Torr.
trulliformis, P. L.M.W. 4:42, 1912. Cameroon.
= Amauroderma fasiculatum (Pat.) Torrend.
turboformis, P. L.M.W. 3:194, 1912. India.
= Aurificaria indica (Mass.) Reid.

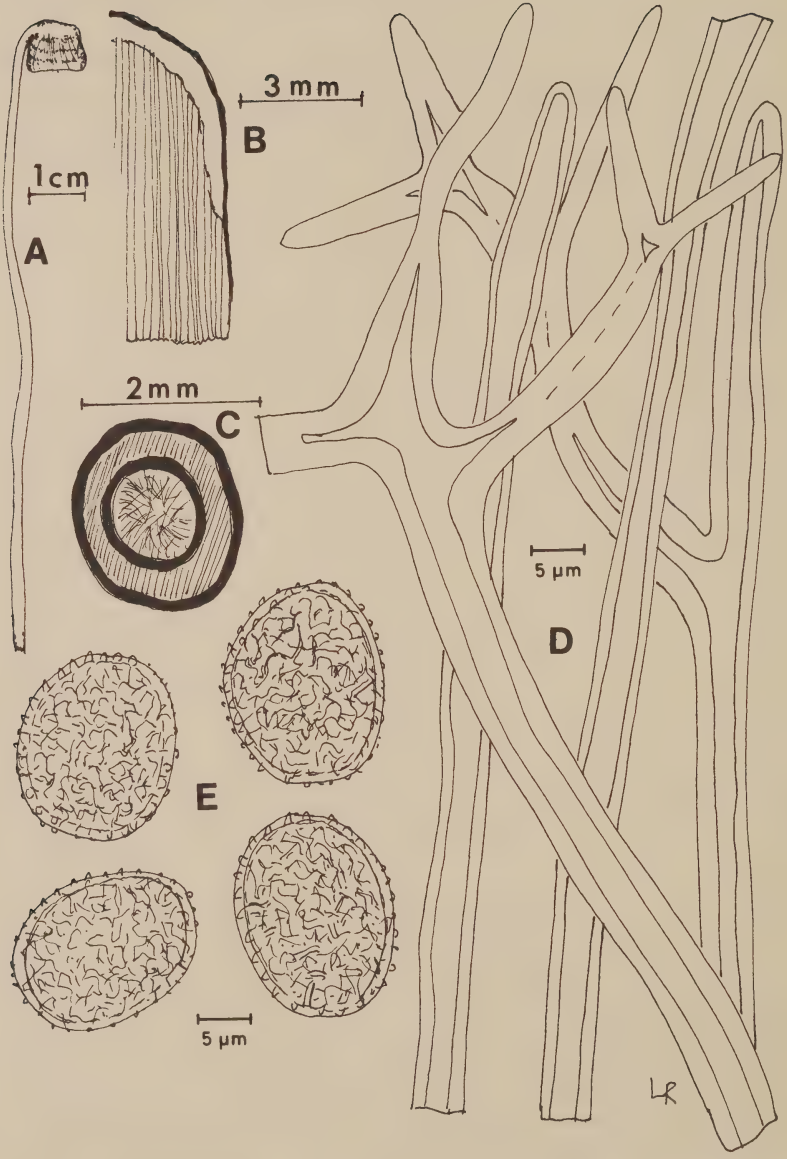
3 mm
B
1cm
A
2 mm
C
5 µm
D
E
5 µm
LR

Fig. 6. Amauroderma unilaterum A) basidiocarp, B) section through pileus, C) section of stipe, D) arboriform skeletal hyphae E) spores. From the lectotype.

unilaterus, Polyporus. L.M.W.3: 117, 1912. Brazil. Fig.6.
= **Amauroderma unilaterum**(Lloyd) Ryv. comb. nov. Basionym as cited above.
Basidiocarp laterally stipitate, pileus semicircular, appr. 1 cm in diameter, 3-6 mm thick, upper surface glabrous, smooth, pale reddish brown and slightly zonate, stipe 15 cm long, 2-3 mm in diameter, round, dark brown, glabrous and smooth, in section with a thin cuticle, cream-coloured context and an inner black longitudinal circular zone inside which there is a loose, almost hollow core filled with a white light mycelium, pore surface pale ochraceous to wood-coloured, pores almost invisible to the naked eye, 7-8 per mm, tubes to 3 mm , pale brown, context to 3 mm white to cream and dense and with a thin crust.
Hyphal system dimitic, generative hyphae with clamps, hyaline, thin-walled and moderately branched, difficult to observe in the type specimen, 2-4 um wide, skeletal hyphae dominating , pale yellowish, slightly dextrinoid, solid to thick-walled, 3-10 um wide, unbranched or arboriform in the apex with few rounded lateral branches, basidia not seen, basidiospores globose to subglobose, thick-walled, pale yellow with irregular ornamentation, in parts with semi-connected sinuous ridges, distinctly dextrinoid, 15-17 x 13-15 um.
Known only from Panure in Brazil.
The species is highly characteristic with the thin and tall stipe with a hollow core, the pale context and the large dextrinoid spores. There is no species corresponding to this characters in the monograph of Furtado (1981).
The round spores and the hollow stipe with a distinct inner black, longitudinal zone are both typical characters for Amauroderma and unknown in Ganoderma which could be an alternative.
unitus, P. L.M.W. 5:699, 1917. Uganda.
= Illegitimate name as a homonym of P. unitus Pers. 1825.
The type of Lloyds illegitimate name is a specimen of Amauroderma oblongisporum Furt.
ursinulus, P. L.M.W. 4:319, 1915. Ecuador.
= Phellinus gilvus (Schw.) Pat.
ursinus, P. L.M.W. 4:319, 1915. USA.
= Amylocystis lapponica (Rom.) Sing.
vanderystii, P. L.M.W. 5:758, 1918. Zaire.
= Polyporus arcularius Fr.

vandykeii, P. L.M.W. 6:944, 1920. Angola.
= Coriolopsis cfr. badius (Berk.) Murr. the type is sterile as is almost all specimens I have examined of this species.
velutinosus, P. L.M.W. 5:66, 1917. India, Hutchings 19027 selected as lectotype here.
= Phellinus senex (Nees & Mont.) Imaz. as indicated by Lloyd (op. cit.).
versiporus, P. L.M.W. 4:54, 1915. Japan.
= Illegitimate name as homonym of P.versiporus Pers. 1825.
The type of Lloyds illegitimate name is a specimen of Dichomitus squalens (Karst.) Reid.
vicinus, P. L.M.W. 7:1331, 1924. South Africa.
= Perenniporia detrita (Berk.) Ryv.
Reid (1975:62) indicated that Lloyds name was a homonym of "P. vicinus Bres.(1920) ". However, he overlooked that Bresadola published his species in Polystictus and not in Polyporus. Thus, Lloyds name is legitimate.
victoriensis, P. L.M.W. 6:1095, 1921. Australia.
= **Inonotus victoriensis** (Lloyd) Pegler. For a description, see Pegler (1964:180) .
= Spongipellis spumeus (Sow.:Fr.) Pat.

wilsonianus, P. L.M.W. 4:53, 1914. Australia.
= Tyromyces campylus (Berk.) Ryv.
yasudai, P. L.M.W. 4:44, 1913. Japan.
= **Albatrellus yasudai** (Lloyd) Pouz. For a description, see Pouzar (1975:200).
yoshinagai, P. L.M.W. 4:54, 1915. Japan.
= Microporellus sp. sterile, young and immature.
zambesianus,P. L.M.W. 3:128, 1912.
= Amauroderma preussii (Henn.) Stey.
zebra, P. L.M.W. 4:339, 1915. Samoa.
= Coriolopsis asper (Jungh.) Teng.
zonatulus, P. L.M.W. 6:883, 1919. Japan.
= Oligoporus floriformis (Quél.) Gilbn. & Ryv.
zonifer, P. L.M.W. 7:1192,1923. Sarawak.
= Perenniporia ochroleuca (Berk.) Ryv.

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CERATOCYSTIOPSIS RANACULOSUS, NOT CERATOCYSTIS MINOR VAR. BARRASII, IS THE MYCANGIAL FUNGUS OF THE SOUTHERN PINE BEETLE

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The name *Ceratocystis minor* var. *barrasii* is rejected. There is no type material, and mating studies and isozyme analysis showed that the only available culture is that of *Ceratocystiopsis ranaculosus*. The described teleomorph of *C. minor* var. *barrasii* is similar to *Ophiostoma minus*, but the anamorph description matches that of *C. ranaculosus*. The latter fungus is one of the two common mycangial associates of *Dendroctonus frontalis*. Another *D. frontalis* associate, *Ophiostoma nigrocarpum*, has been confused with the anamorph of *C. ranaculosus*, but isozyme analysis showed that the species are distinct.

The southern pine beetle (SPB, *Dendroctonus frontalis* Zimm.) has a prothoracic mycangium (Francke-Grosmann 1965), in which either of two fungi may be found (Barras and Perry 1972). One of these fungi is an unnamed basidiomycete with clamp connections and dolipore septa, but neither basidia nor basidiospores have been reported. The second fungus has been referred to as SJB 133, *Sporothrix* sp., *Raffaelea* sp. and *Ceratocystis minor* var. *barrasii* Taylor. *Ophiostoma minus* (Hedg.) H. & P. Sydow (Syn. *Ceratocystis minor* var. *minor*) is also commonly associated with SPB, but it is not found in the mycangium. We have also found the *Sporothrix* anamorph of *Ophiostoma nigrocarpum* (Davids.) de Hoog growing in galleries of SPB, but repeated attempts have failed in isolating the fungus from mycangia.

The name *Ceratocystis minor* var. *barrasii* was rejected by Upadhyay (1981) for lack of ascocarp material to serve as holotype. We concur with Upadhyay that this is not the proper name for the mycangial fungus and propose that the name *Ceratocystiopsis ranaculosus* Bridges & Perry be applied. Mating studies and isozyme analyses, in conjunction with morphological comparisons, were used to delineate *C. ranaculosus* from the other SPB associates with which it has been confused.

MATERIALS AND METHODS

All isolates examined have been deposited in the University of New Hampshire culture collection. Those used in matings and isozyme analyses are listed in Tables 1 and 2, along with the location and substrate from which they were isolated.

Matings were conducted on pine twig medium, consisting of water agar (1.5%) with cross and split, longitudinal sections of autoclaved twigs of *Pinus strobus* L. (with bark attached) in 50-mm-diam. petri dishes. Plugs of mycelium grown on malt-yeast extract agar (1.5% malt extract, 0.1% yeast extract, 1.5% agar) were placed on opposite sides of the twigs, which were oriented with the freshly-exposed xylem of the twigs facing up. Plates were incubated at room temperature under normal laboratory lighting and examined at 5 to 12 wk for the presence of mature ascocarps.

Isozyme analysis was conducted as previously described (Zambino and Harrington 1989). Cultures were grown on malt-yeast extract broth (2% malt extract, 0.1% yeast extract) in still culture for 14 days. Enzymes were extracted in buffer solution and stored on chromatography-paper wicks at -80 C. The enzymes tested are listed in Table 3 along with the buffer systems. Staining procedures were those of Marty et al. (1984), except for mannitol dehydrogenase (Micales et al. 1986). Multiple enzyme forms were numbered in order of decreasing anodal migration. Electromorphs of a given enzyme form were designated alphabetically in order of decreasing anodal migration.

RESULTS AND DISCUSSION

Although a thorough description, good illustration of anamorphs and a proper Latin diagnosis were given for *Ceratocystis minor* var. *barrasii* (Barras and Taylor 1973), no type material was designated and the taxon remains a *nomen dubium.* Bridges deposited a culture in the American Type Culture Collection (ATCC 36945, C200 in the UNH collection) that had

Table 1. Isolate number, location of origin and source of *Ceratocystiopsis ranaculosus* isolates used in mating studies or starch gel electrophoresis.

ISOLATE NUMBER	LOCATION OF ORIGIN	SOURCE	INFORMATION
C200	Unknown	Barras[1]	ATCC 36945; from SPB; identified as *C. minor* var. *barrasii*
C210	Unknown	Perry[2]	From SPB mycangium; identified as *C. minor* var. *barrasii*
C211	Unknown	Perry	FRRC C-1245[3]; from SPB mycangium; deposited as *C. minor* var. *barrasii*
C237	South Carolina	Zambino[4]	From SPB mycangium
C244	Arkansas	Unknown	From SPB
C263-9	South Carolina	Zambino	From SPB mycangium
C282	Louisiana	Perry	From ascospores in SPB-attacked *Pinus taeda*
C285	Unknown	Perry	From SPB mycangium; identified as *C. minor* var. *barrasii*
C287	Unknown	Perry	From SPB mycangium; identified as *C. minor* var. *barrasii*
C331	Louisiana	Perry	From ascospores in SPB-attacked *P. taeda*
C335	Louisiana	Zambino	From ambrosial growth in SPB gallery in *P. taeda*
C337	Louisiana	Zambino	From SPB mycangium
C341-2	Louisiana	Zambino	From SPB mycangium
C360	Georgia	Smalley[5]	From *Ips avulsus*
C379	Louisiana	Zambino	From SPB
C383	Louisiana	Zambino	From SPB
C385-6	Louisiana	Zambino	From SPB

[1] Deposited in the American Type Culture Collection by J. R. Bridges.

[2] Isolated by T. J. Perry.

[3] Northern Forestry Centre, Edmonton, Alberta, Canada.

[4] Isolated and identified by P. J. Zambino. Mycangial contents of South Carolina beetles were scraped with a sterile needle and plated onto MEA. Mycangial isolates from Louisiana beetles were made by plating surface-sterilized pronotums onto MEA.

[5] Isolated by E. B. Smalley.

Table 2. Isolate number, location of origin and source of *Ophiostoma minus* and *Ophiostoma nigrocarpum* isolates used in starch gel electrophoresis.

ISOLATE NUMBER	LOCATION OF ORIGIN	SOURCE	INFORMATION
Ophiostoma minus			
C106	Nebraska	Hinds[1]	From *Pinus banksiana*
C188	California	Owen[2]	From *D. brevicomis*
C189	California	Owen	From *D. brevicomis*-attacked *P. ponderosa*
C198	Unknown	Davidson[3]	From *P. contorta*
C218	South Carolina	Zambino[4]	From ascospores SPB-attacked *P. echinata*
C219	South Carolina	Zambino	From blue-stained wood in SPB-attacked *P. echinata*
C242	Idaho	Zambino	From blue-stained wood in *P. edulis*
Ophiostoma nigrocarpum			
C208	Unknown	Perry[5]	From *Pinus* sp. attacked by SPB; identified as anamorph of *C. ranaculosus*
C212	Unknown	Perry	From *Pinus* sp. attacked by SPB; identified as *Sporothrix* sp.
C226	South Carolina	Zambino	From conidia in SPB-attacked *P. echinata*
C233	South Carolina	Zambino	From SPB
C283	Louisiana	Perry	From SPB-attacked *P. taeda*; identified as *C. ranaculosus*
C284	Unknown	Perry	From SPB-attacked *P. taeda*; identified as *Sporothrix* sp.

[1] Isolated and identified by T. E. Hinds.
[2] Isolated and identified by D. R. Owen.
[3] Isolated and identified by R. W. Davidson.
[4] Isolated and identified by P. J. Zambino
[5] Isolated by T. J. Perry.

Table 3. Enzymes and buffers used in starch gel electrophoresis.

Abbreviation	Enzyme	EC Number[1]	Buffer System[2]
AAT	Aspartate aminotransferase	2.6.1.1	A,E,M
ACO	Aconitase	4.2.1.3	D,HC7
DIA	Diaphorase	1.8.1.4	A,M
IDH	Isocitrate dehydrogenase	1.1.1.42	E
MAN	Mannitol dehydrogenase	1.1.1.67	D,E,HC7,M
MDH	Malate dehydrogenase	1.1.1.37	D,E
PGI	Glucosephosphate isomerase	5.3.1.9	D,H
PGM	Phosphoglucomutase	5.4.2.2	E,M
SDH	Sorbitol dehydrogenase	1.1.1.15	A

[1] Nomenclature Committee of the International Union of Biochemistry (1984).

[2] Buffer systems and electrical requirements are described in Zambino and Harrington (1989).

as *C. minor* var. *barrasii* by Barras. This culture may have been among those examined for the original species description, and it does form conidial states identical to those described by Barras and Taylor (1973). Unfortunately, this culture does not form ascocarps unless mated with other isolates.

We mated C200 with other isolates from mycangia of *Dendroctonus frontalis*, and in some pairings, mature ascocarps with ascospores developed (Tables 4 and 5). Surprisingly, these ascocarps did not resemble those described by Barras and Taylor (1973) but appeared to be those of the recently described *Ceratocystiopsis ranaculosus* (Bridges and Perry 1987). Barras and Taylor's description of *C. minor* var. *barrasii* would appear to be that of two distinct fungi. Their description of the ascocarps and ascospores may be that of *Ophiostoma minus*, whereas their description of the anamorph matches that of *C. ranaculosus* as we recognize it.

Ceratocystiopsis ranaculosus was described as an associate of SPB (Bridges and Perry 1987), but it was not originally recognized as one of the mycangial inhabitants. Unmated mycangial isolates that we have examined do not produce ascocarps in vitro, but matings among mycangial isolates occasionally resulted in mature ascocarps and ascospores. Some of the isolates tested failed to produce ascocarps, regardless of the isolates with which they were paired. Those that produced ascocarps did so with only some of the isolates (Tables 4 and 5), and the pattern of compatibility suggested that the fungus is heterothallic, with two alleles for compatibility (MAT-1 and MAT-2). Thus, failure of an unpaired mycangial isolate to produce ascocarps in vitro may be due, in part, to isolation of one mating type. It should be noted, however, that genetic evidence for mating was not obtained (single ascospore progeny were not recovered for analysis of genetic segregation).

Isozyme analysis also supported the contention that the mycangial fungus previously referred to as SJB 133 or *C. minor* var. *barrasii* is *C. ranaculosus.* Electromorphs of nine enzymes, representing 11 putative loci, were examined from 15 isolates of *C. ranaculosus*, including some isolates originally identified as *C. minor* var. *barrasii* (Table 1). The 15 isolates had identical electromorphs for seven of the putative loci; two or three electromorphs were found for each of the other four putative loci (Table 6).

Table 4. Mating among isolates of *Ceratocystiopsis ranaculosus* on pine twig media in the first of two experiments and putative mating type alleles (MAT-1 or MAT-2).

	287	268	266	263	269	267	265	264	244	237	200
MAT-1											
200	+[1]	+	+	-	-	-	-	-	-	-	-
237	-	-	+	-	-	NT	-	-	NT	-	
244	NT	+	+	-	-	-	NT	-	-		
264	-	-	+	+	-	-	-	-			
265	-	-	+	-	-	NT	-				
267	NT	-	+	-	-	-					
269	-	+	+	+	-						
MAT-2											
263	-	-	-	-							
266	-	-	-								
268	-	-									
287	-										

[1] Production (+) or absence (-) of mature ascocarps was noted at the end of 6 wk. Pairings not tested are indicated by NT. Isolates 210, 211, 244 and 285 failed to form ascocarps with other isolates in this first pairing.

The same enzymes were analyzed in seven isolates of *Ophiostoma minus*, but no common electromorph was found between this species and *C. ranaculosus* (Table 6). Thus, isozyme comparisons indicate no relationship between the mycangial *C. ranaculosus* and *O. minus*. The conidiophores of *O. minus* and *C. ranaculosus* are morphologically similar (Fig.1), but their teleomorphs are very different. *Ophiostoma minus* is a typical member of *Ophiostoma*; it has flask-shaped ascocarps with short necks, through which masses of lunate-shaped ascospores emerge in a sticky drop. *Ceratocystiopsis ranaculosus* also produces necked ascocarps with sticky ascospore masses, but it does not clearly fit into *Ophiostoma* or *Ceratocystiopsis*. The ascocarp shape (like an acorn) and pattern of ascospore development (filamentous spores with a bulbous swelling developing at one end) are apparently unique to this fungus.

Table 5. Mating among isolates of *Ceratocystiopsis ranaculosus* on pine twig media in the second of two experiments and putative mating type alleles (MAT-1 or MAT-2).

	386	383	360	341	263	385	379	342	337	335	267	264	244	200
MAT-1														
200	-[1]	+	-	-	-	-	-	-	-	-	-	-	-	-
244	-	+	-	-	-	-	-	-	-	-	-	-	-	
264	-	+	-	-	-	-	-	-	-	-	-	-		
267	-	+	-	-	-	-	-	-	-	-	-			
335	-	+	-	+	+	-	-	-	-	-				
337	-	+	-	-	-	-	-	-	-					
342	-	+	-	-	+	-	-	-						
379	-	+	-	-	-	-	-							
385	+	+	+	-	-	-								
MAT-2														
263	-	-	-	-	-									
341	-	-	-	-										
360	-	-	-											
383	-	-												
386	-													

[1] Production (+) or absence (-) of mature ascocarps was noted at the end of 12 wk. Isolates 266, 269 and 287 failed to form ascocarps with other isolates in this second pairing, but did so in the first pairing.

Table 6. Isozyme electromorphs of isolates of *Ceratocystiopsis ranaculosus*, *Ophiostoma minus* and *Ophiostoma nigrocarpum*.

SPECIES	ISOLATE	AAT1[1]	ACO1	DIA1	IDH1	MAN1	MDH1	MDH2	PGI1	PGM1	PGM2	SDH1
Ceratocystiopsis ranaculosus												
	200	C[2]	A	A	C	E	A	E	C	F	G	F
	210	C	A	A	C	E	A	E	C	ND[3]	G	F
	211	C	A	A	C	E	A	E	C	G	G	F
	244	C	A	A	C	E	A	E	E	F	G	F
	263	C	A	A	C	E	A	E	C	F	H	F
	264	C	A	A	C	E	A	E	F	H	G	H
	265	C	A	A	C	E	A	E	C	F	G	F
	266	C	A	A	C	E	A	E	C	F	G	F
	267	C	A	A	C	E	A	E	C	G	G	F
	268	C	A	A	C	E	A	E	C	F	G	F
	269	C	A	A	C	E	A	E	C	G	G	F
	282	C	A	A	C	E	A	E	C	F	G	F
	285	C	A	A	C	E	A	E	C	F	G	F
	287	C	A	A	C	E	A	E	C	F	G	F
	331	C	A	A	C	E	A	E	C	F	G	E

Ophiostoma minus											
106	D	E	D	D	F	E	B	H	C	I	D
188	D	E	D	D	F	E	B	H	C	K	D
189	D	E	D	D	F	E	B	H	C	K	D
198	D	G	D	E	F	E	D	H	C	J	D
218	D	E	D	D	F	E	B	H	C	I	D
219	D	E	D	D	F	E	B	H	C	K	D
242	D	E	D	D	G	E	B	H	C	I	D
Ophiostoma nigrocarpum											
208	A	D	C	A	B	C	A	D	B	C	A
212	A	D	C	A	B	C	A	D	B	C	A
226	A	D	C	A	B	C	A	B	B	C	A
233	A	D	C	A	B	C	A	D	B	C	A
283	A	D	C	A	B	C	A	D	B	C	A
284	A	D	C	A	B	C	A	D	B	C	A

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[1] Multiple enzyme forms are designated in order of decreasing anodal migration.

[2] Electromorphs of a given enzyme form are designated alphabetically in order of decreasing anodal migration.

[3] Electromorph not determined.

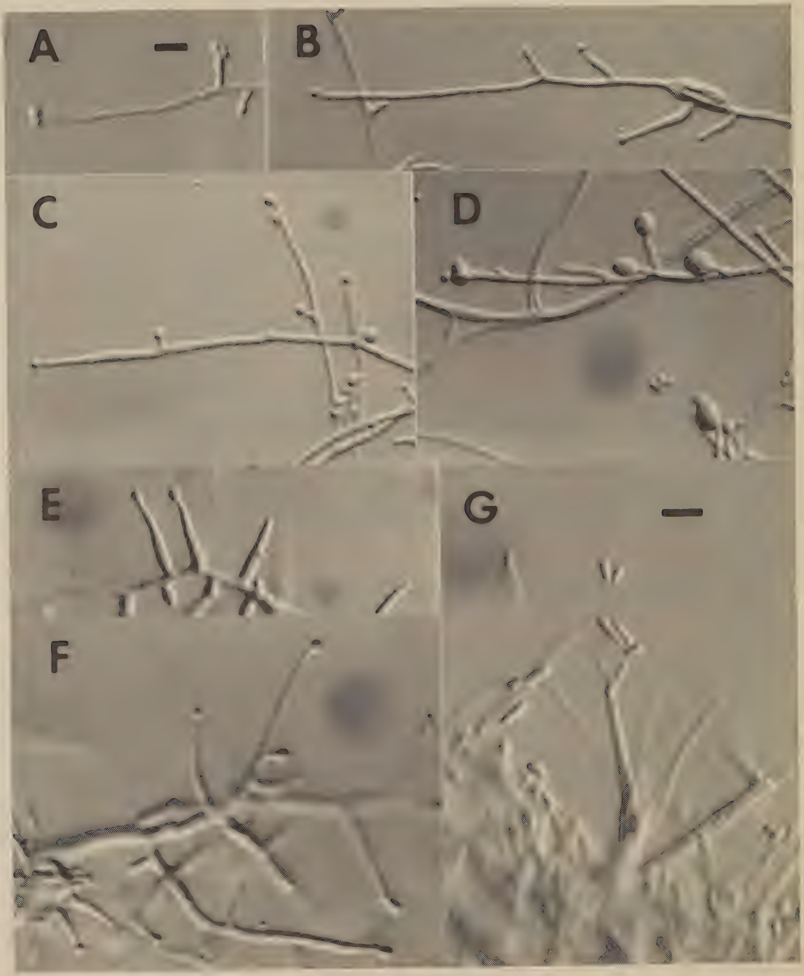

Figure 1. Conidiophores and conidia of *Ceratocystiopsis ranaculosus* (A-D), *Ophiostoma minus* (E, F) and *O. nigrocarpum* (G). A through F are at the same magnification. Bars in A and G designate 10 µm, with G magnified slightly more than A.

Bridges and Perry (1987) illustrated and described the teleomorph of *C. ranaculosus* well, but their description of cultures is inconsistent with our observations and differs from the description of *C. minor* var. *barrasii* given by Barras and Taylor (1973). The conidiophores and conidia described and illustrated by Bridges and Perry (1987) appear to be those of another fungal associate of the southern pine beetle, *Ophiostoma nigrocarpum*. Cultures of *O. nigrocarpum* and *C. ranaculosus* are similar in growth rate and pigmentation, but the conidia of *C. ranaculosus* are more ovoid (Fig. 1). *Ophiostoma nigrocarpum* has elongate conidia (Fig. 1G), similar to those illustrated by Bridges and Perry (1987) as *C. ranaculosus*. In addition to small conidia, large, ovoid conidia that may have slightly thickened walls (Fig. 1D) may be found in dense tufts in some cultures of *C. ranaculosus* and are also found in some pupal chambers of the SPB (Barras and Perry 1972). These larger spores appear similar to those of ambrosial fungi and may serve a similar role, i.e., as food for their beetle symbionts (Barras and Perry 1972, Barras and Taylor 1973).

Isozymes of six isolates of *O. nigrocarpum* (Table 2), including two isolates previously identified as *C. ranaculosus*, were compared with those of *C. ranaculosus*. The two taxa had differing electromorphs for each of the 11 putative loci that were tested (Table 6). Also, our attempts to mate *C. ranaculosus* with *Ophiostoma nigrocarpum* have, expectedly, failed to produce ascocarps. The anamorph illustrated by Bridges and Perry (1987), therefore, does not appear to be that of *C. ranaculosus*.

The *Sporothrix* state of *O. nigrocarpum* is abundant in beetle galleries, and we have frequently isolated the fungus from SPB adults. However, we have not found ascocarps of *O. nigrocarpum* in SPB-attacked trees. Some isolates of the *Sporothrix* sp. produce ascocarps typical of *O. nigrocarpum* when paired in culture, and it may be a heterothallic species. In morphology and in isozyme comparisons, it appears to be conspecific with a hyphomycete associated with the western pine beetle (*Dendroctonus brevicomis* LeConte). The hyphomycete associated with *D. brevicomis* is the putative anamorph of *O. nigrocarpum* and has been associated with the mycangium of this beetle (Whitney and Cobb 1973; Owen et al. 1987).

Thus, it would thus appear that, besides the unnamed basidiomycete, there are at least three distinct taxa commonly associated with SPB. The mycangial fungus is *Ceratocystiopsis ranaculosus*. This species is unrelated to *Ophiostoma minus*, a non-mycangial associate of the beetle. The name *Ceratocystis minor* var. *barrasii* is rejected because of lack of type material and the incongruity between the teleomorph description and ascocarps formed when the only available culture was mated with other mycangial isolates. Barras and Taylor's (1973) description of *C. minor* var. *barrasii* apparently combined features of two taxa; the conidial states described are the anamorphs of *C. ranaculosus*. Conidia and conidiophores of a third associate of SPB, *O. nigrocarpum*, have also been confused with the anamorph of *C. ranaculosus*. However, the non-mycangial *O. nigrocarpum* does not mate with *C. ranaculosus* and is distinct, both morphologically and in its isozyme electromorphs.

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The cooperation of all those who supplied fungal isolates, particularly Thelma Perry and J. Robert Bridges, is greatly appreciated. Fred P. Hain kindly provided bark beetles from South Carolina for our isolations. Meredith Blackwell, Robert O. Blanchard, Eugene B. Smalley and H. S. Whitney kindly reviewed the manuscript. This material is based upon work supported by the Cooperative State Research Service, U. S. Department of Agriculture under Agreement No. 88-37253-4112 and Western Regional Project W-110. Scientific Contribution No. 1666 from the New Hampshire Agricultural Experiment Station.

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MYCOTAXON

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A NEW COMBINATION IN PARENCOELIA*

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In his recent paper referring to hyaloscyphaceous species originally described by C. H. Peck, Haines (1989) noted *Peziza kalmiae* on *Phyllachora kalmiae* on small branches of *Kalmia angustifolia* from New York, USA. Its brown excipular cells, ellipsoid ascospores, and occurance on *Phyllachora* drew my special interest. Through the kindness of Dr. Haines I have had a chance to examine the type specimen of this fungus. It turns out to be a member of *Parencoelia,* a fungus-inhabiting discomycete genus. It contained, until now, three species from a few regions of tropical South America (Petrak, 1950; Zhuang, 1988). The genus was believed to be tropical but discovery of the North American species proves that it might be much more widely distributed, and more taxa may be found.

Parencoelia andina seems to be the closest species to the North American fungus, which can be distinguished by smaller apothecia, darker ectal excipular cells, clearly defined medullary excipulum, shorter and wider asci of J- iodine reaction, and larger ellipsoid ascospores. Peck (1873) provided a brief description of the fungus in the fresh condition. I redescribe and illustrate this fungicolous discomycete to give a complete specific concept. A new combination in *Parencoelia* is made as follows:

Parencoelia kalmiae (Peck) W.-y. Zhuang, *comb. nov.*
= *Peziza kalmiae* Peck, Ann. Rep. New York State Mus. 25: 99, 1873.
= *Dermatea kalmiae* (Peck) Cooke, Bull. Buffalo Soc. Nat. Sci. 3: 24, 1875 [superfluously recombined as *Dermatea kalmiae* (Peck) Ellis & Everh., North Am. Fung. #147, 1879].
= *Pezicula kalmiae* (Peck) Sacc., Syll. Fung. 8: 314, 1889.
= *Trichopeziza kalmiae* (Peck) Sacc., Syll. fung. 8: 411, 1889.

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* Supported by the National Natural Science Fundation of China.

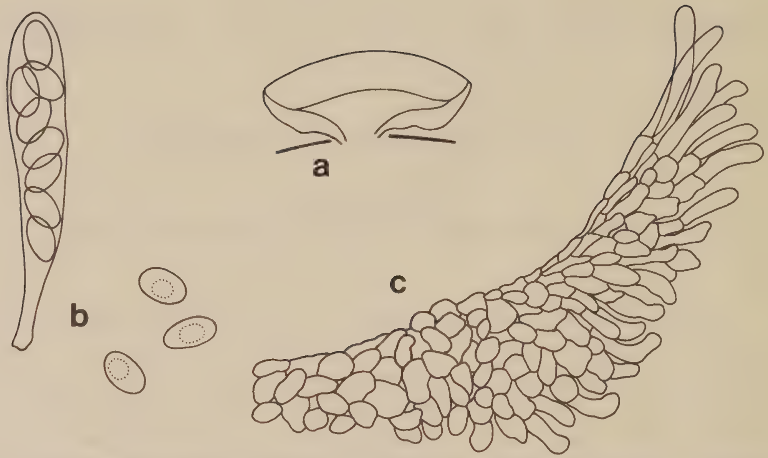

Fig. 1. *Parencoelia kalmiae* (holotype): **a**. shape of apothecium, from top to bottom showing hymenium, medullary excipulum, and ectal excipulum; **b**. an ascus and ascospores; **c**. structure of ectal excipulum. **a** x 73, **b** x 835, **c** x 525.

Apothecia plane when fresh, discoid to flat when dry, convex when rehydrated, sessile, mostly 0.25-0.35 mm in diam when dry,hymenium pinkish brown when fresh and brown, grayish brown to darker when dry, receptacle dull gray when fresh and brown when dry, surface furfuraceous. Ectal excipulum of textura angularis, 20-40 µm thick, cells spherical to ellipsoid, thin-walled, brown, 4.5-8.0 µm in diam if isodiametric, margin with short free hyphal protrusions extending towards outside. Medullary excipulum of textura angularis, distinguished from ectal excipulum, absent at margin, 18-25 µm at flanks, cells pale to light brown, with many pale yellow, refractive crystals. Asci mostly 8-spored, J- in Melzer's reagent with or without 10% KOH pretreatment, ca. 66-70 x 8.5-10.0 µm. Ascospores ellipsoid, hyaline, irregularly uniseriate to irregularly biseriate, uniguttulate, rarely biguttulate, 7.0-8.5 x 4.0-4.8 µm when mounted in cotton blue lactic acid, swollen when mounted in Melzer's reagent, 7.0-10.0 x 5.0-6.7 µm. Paraphyses filiform, ca. 2 µm wide. On *Phyllachora kalmiae (Dothidea kalmiae* according to the original author) on dead stems and branches of *Kalmia angustifolia.*

Holotype examined: on *Kalmia angustifolia* (according to the original author: on dead stems and branches of *Kalmia angustifolia* extending also on *Dothidea kalmiae;* my observations: the vast majority of apothecia on fruitbodies of *Phyllachora kalmiae*), Sandlake, New York, USA, C. H. Peck, (according to the original author: September), NYS.

ACKNOWLEDGEMENTS

The author would like to thank Dr. John H. Haines of the New York State Museum, USA, for sending the type specimen on loan; Prof. Richard P. Korf of Cornell University, USA, for serving as pre-submission reviewer; and Ms. Zhe-fang Han of the Institute of Microbiology, Academia Sinica, for inking the drawings.

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MYCOTAXON

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CALYCELLINOPSIS XISHUANGBANNA GEN. ET SP. NOV. (DERMATEACEAE), A PETIOLE-INHABITING FUNGUS FROM CHINA*

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In a collecting trip to Xishuangbanna, Yunnan Province, China in October of 1988, many discomycetes were found in the woods and along streambeds. Specimens were collected extensively and cultures made for selected groups. Among them a small, light-colored, petiole-inhabiting fungus drew my special attention. It has uncommon anatomical structure. The combination of the dark brown outer cells surrounding light brown inner cells at the apothecial base, gel covering the lower flanks, characteristic short cell protrusions on the receptacle surface, and highly refractive medullary excipular cells make it difficult to place it in any existing genus. It is treated here as a new species in a new genus.

Calycellinopsis xishuangbanna W.-y. Zhuang, *gen. et sp. nov.* (Fig. 1)

Apothecia calyciformia vel applanata, sessilia vel substipitata, gelatina in basi apothecii; receptacula cum perbrevibus processibus conica vel bacillaria; excipulum ectale ex texturae angularis, cellula pigmento leviter in parte superiore et perobscura in loco affixo ad substratum; excipulum medullae ex textura angulari vel textura globulosa et commixto paucis hyphis, cellulari muro hyalino; asci inoperculati, 8 sporis, longo-clavati, J+; ascosporae hyalinae, fusoideae, unicellulares, guttulatae; paraphyses filiformes.

Apothecia shallow discoid to flat, sessile to substipitate, 1 mm in diam, hymenium buff when fresh, receptacle slightly grayer than hymenium. Ectal excipulum of textura angularis, 7-13 µm thick, cells subisodiametric to somewhat brick-shaped, long axes of cells parallel to the outer surface, walls light brown at flanks and dark brown at the point of attachment to substrate, ectal excipulum near and at apothecial base submerged in or covered with gel, inner cells

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* Supported by the National Natural Science Fundation of China.

at the apothecial base lighter than the outer cells. Short cell protrusions distributed at margin and flanks except for the basal portion, conical to rod-shaped, hyaline, unicellular, perpendicular to the outer surface, 8-15 x 4-6 µm, walls smooth to slightly roughened. Medullary excipulum of textura angularis to textura globulosa, mixed with a few interwoven hyphae, cell contents highly refractive, walls hyaline and smooth. Asci 8-spored, elongate-clavate, J+ in Melzer's Reagent and pore walls faintly blue as two lines, arising from a crozier, 55-60 x 3.5-4.0 µm. Ascospores biseriate to irregularly biseriate, fusoid with sharply pointed ends, with 2-5 small guttules, 8-11 x 1.2-1.7 µm. Paraphyses cylindrical, 2 µm wide, not exceeding asci. On petioles.

In culture, colony on potato dextrose agar (PDA) yellowish white with a rosy to pinkish tint, growing radially, sometimes with concentric rings; spermatia produced abundantly, rosy in slimy mass, *Myrioconium*-like, subspherical to ovoid, hyaline, ca. 1.8 µm in diam; a few apothecia produced, hymenium surface convex to flat, gregarious, disc greenish brown, 1.3-2.0 mm in diam.

Holotype: on petioles of an unidentified plant, Limestone Hill, Xishuangbanna, Yunnan, China, alt. 650 m, R. P. Korf, M. Zang, K.-k. Chen, & W.-y. Zhuang (W.Y.Z. 215), 22. X. 1988, HMAS 58722.

Notes: The outer dark cells surrounding the central light brown ones in transverse section at the very base of apothecium of *Calycellinopsis xishuangbanna* recalls the genus *Calycellina* in which the apothecium has a brown basal ring at the point of attachment to the substrate. But the arrangement, orientation, and color of the ectal excipular cells, the refractiveness of medullary excipular cells, and the shape and orientation of the cell protrusions on the receptacle surface are quite different from those of *Calycellina*. Like members of *Pezoloma*, a distinct gel layer is present near and at the apothecial base of this fungus, but this is essentially the only characteristic shared by *Calycellinopsis* and *Pezoloma*. The excipular structure and color of the ectal excipular cells do not fit *Pezoloma* at all. It is necessary to give some thought to the taxonomic position of this tropical inoperculate discomycete. Since the ectal excipular cells are angular and with brownish walls I tentatively place it in the Dermateaceae, but have no idea of any

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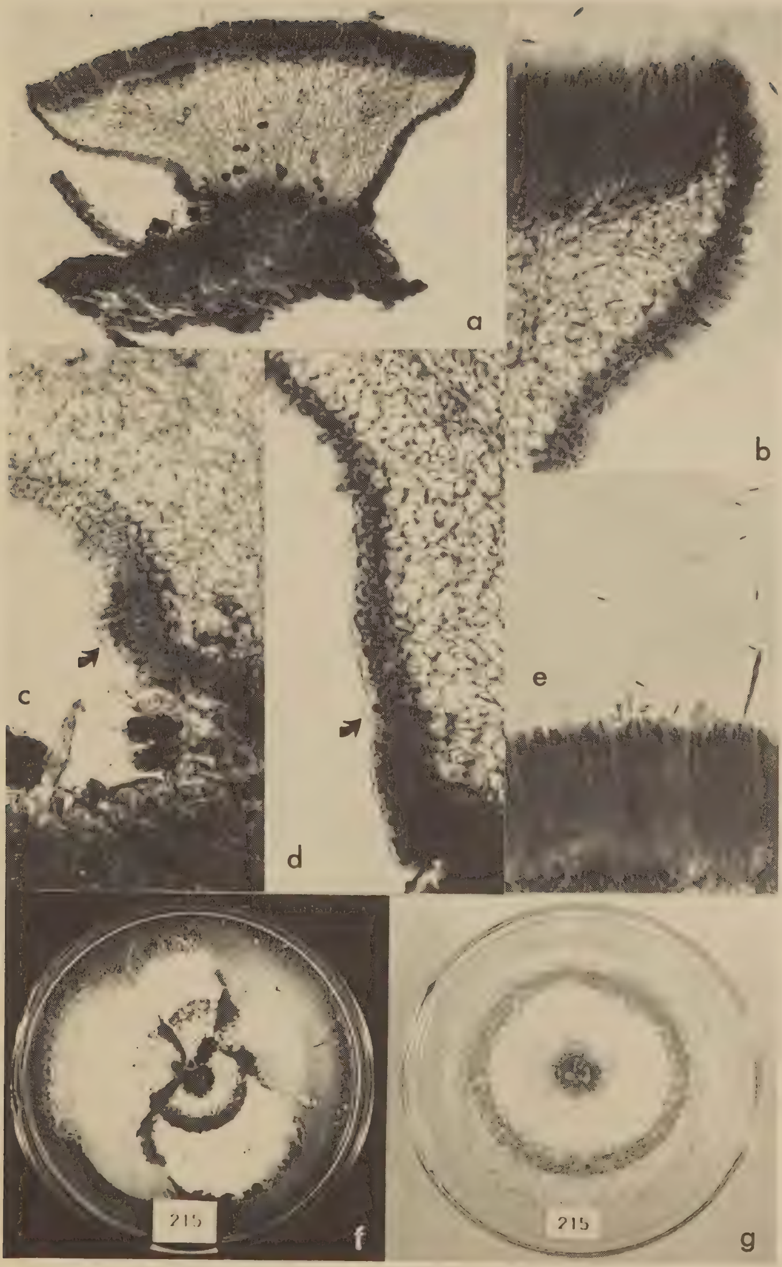
Fig. 1. *Calycellinopsis xishuangbanna* (holotype): **a**. anatomy of apothecium, note dark tissues at the point of attachment to substrate; **b**. hairs and excipular structure at margin and flank; **c**, **d**. excipular structure at apothecial base and lower flank, showing gel tissue; **e**. asci and ascospores; **f**, **g**. colony morphology on PDA; **a** x 73, **b-e** x 300.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closely related genus in the family. Placement in the Leotiaceae is not considered mainly due to the different ectal excipular structure.

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I deeply thank Prof. Richard P. Korf of Cornell University, USA for his help with collecting and culturing the fungus, serving as pre-submission reviewer of this paper, and editorial assistance. Prof. Ji-ding Zhao of the Institute of Microbiology, Academia Sinica, kindly corrected the Latin diagnosis and Ms. Lan-cui Yuan helped with preparing photographs.

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AMANITA SALMONESCENS—A NEW SPECIES FROM THE SOUTHEASTERN UNITED STATES

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Summary

Amanita salmonescens is described as new from New Jersey and South Carolina.

Amanita salmonescens Tulloss, sp. nov. Holotypus: South Carolina, Oconee County, Sumter National Forest, Stumphouse Tunnel Park, M. A. King & R. E. Tulloss 7-16-83-A (NY[1]).

Pileus albus, 35 - 57 *mm in mensura diametrica, convexus, partes contusae tarde rufobrunnescentes; margine nonstriata, parum appendiculata; materies volvica alba, cinerea vel subnigra ut senescit. Lamellae albae vel subalbidae, condensae, plus minusve liberae. Stipes* 20 - 53 × 10 *mm, albus, subsalmonescens, annulatus; annulus subapicalis, membranaceus, albus, subsalmonescens. Basidiae tetrasterigmaticae,* 30 - 42 × 7.7 - 11 *µm; fibulae absentes. Sporae* (5.9-) 6.6 - 9.1 (-10.5) × (4.2-) 4.5 - 5.9 (-6.3) *µm, late ellipsoideae vel ellipsoideae vel elongatae, amyloideae.*

Amanita salmonescens (Figs. 1-2) is a medium-sized, white mushroom with a subapical, membranous annulus; an universal veil left as graying, small, pyramidal warts on the pileus; a slightly appendiculate pileus margin; and few universal veil remnants on its ovoid bulb. Basidiocarps of this species have the property that bruising the stipe and partial veil produces a distinct discoloration—sordid pinkish or sordid pale salmon. Damaged areas of the pileus become dark reddish-brown slowly. *Amanita salmonescens* represents another taxon in the small group which, while having some characters typical of section *Validae*, have other properties suggesting a relationship with section *Lepidella*. *Amanita salmonescens* is placed in section *Validae*.

PILEUS: white to off-white, subviscid to dry and shiny, 35 - 57 mm diam, at first globose, at maturity planar with depressed center; margin at first inflexed, becoming rimose, nonstriate, finely appendiculate or not appendiculate; universal veil remnants as large, coarse, subpyramidal to truncate pyramidal warts with polygonal base, at times

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[1] NY - Herbarium of the New York Botanical Garden, Bronx, U.S.A.

Collections without herbarium designation are in my private herbarium.

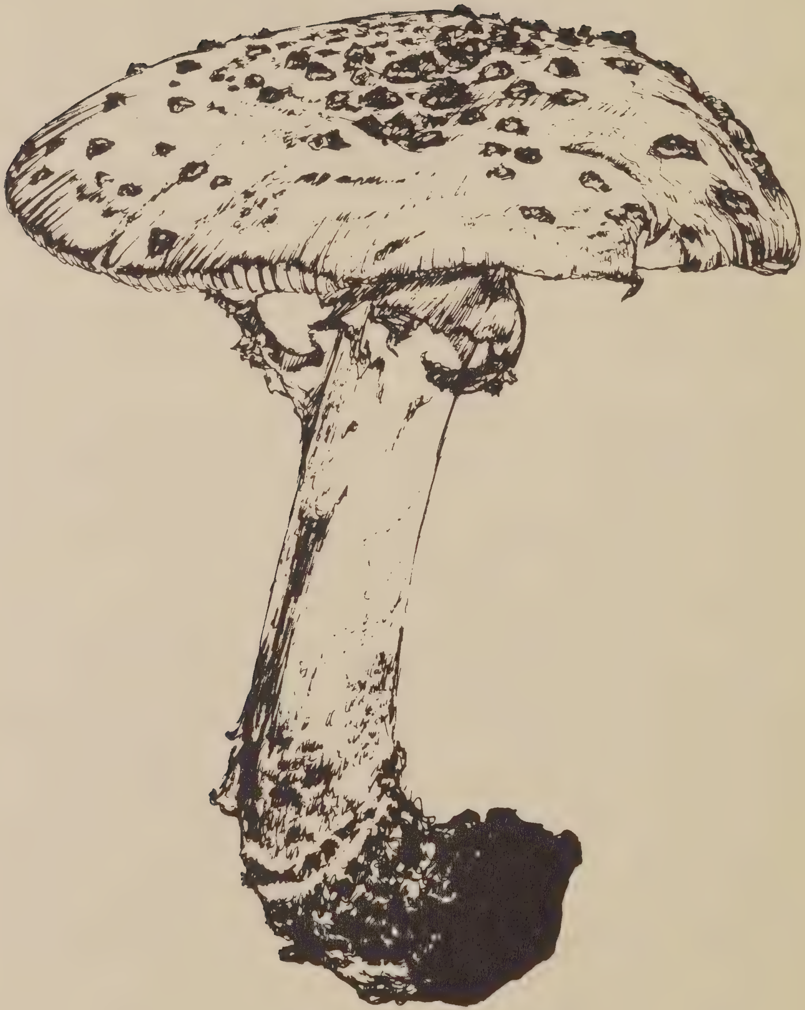

Fig. 1 *Amanita salmonescens*. Habit (King & Tulloss 7-16-83-A) [×1.8].

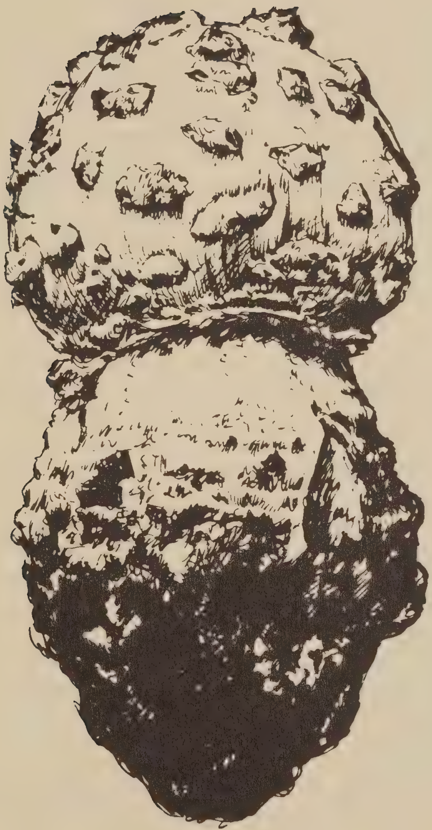

Fig. 2 *Amanita salmonescens*. Habit in early development (King & Tulloss 7-16-83-D) [×2.5].

confluent, lifting at the edges, white at first becoming gray to blackish at maturity; pileipellis slowly turning dark reddish-brown where cut, sometimes with pinkish discoloration around the darkened edges; context white, sometimes faint pinkish in areas of insect damage and sometimes taking on a dark reddish-brown color near pileipellis, up to 5 mm thick at stipe. LAMELLAE: white to whitish, sometimes browning in spots, close to crowded, free to occasionally adnate, all with decurrent line, up to 5 mm broad; lamellulae truncate to rounded truncate to subattenuate. STIPE: white becoming pinkish (close to "reddish (or pinkish) white" (7A2), but with a gray tint)[2] or pallid orange gray, 20 - 53 × 10± mm, narrowing upward, flaring at apex, surface undecorated to finely fibrillose to fibrillose and with pellis recurving in thin scales and fibrils discoloring like pileipellis, pruinose above partial veil; bulb subnapiform to elongate-subclavate, rooting, 25 - 35 × 15 - 22 mm; universal veil sometimes in up to three or four concentric circles of dash-like warts on upper portion of bulb, white becoming grayish or pallid orange gray and sometimes disappearing; context white, solid, occasionally brownish in bulb probably due to injury; pellis brown in section in aging specimen; partial veil subapical, membranous, becoming lacerate and appressed to stipe, white becoming pinkish to pallid orange gray like the stipe, margin thickened, striate above, lacerate fibrillose below, sometimes with fibrils from stipe attached below. Odor pleasant, pungent, flowery or fruit-like to faintly so. Taste not recorded.

PILEIPELLIS: branching interwoven radially-arranged barely gelatinizing filamentous undifferentiated hyphae 1.2 - 16.0 μm diam; oleiferous hyphae present, 2.5 - 6.2 μm diam, some containing guttulate material that stains deeply in Congo Red. PILEUS CONTEXT: scattered granules throughout tissues which stain deeply in Congo Red; branching interwoven filamentous undifferentiated hyphae 4.8 - 13.0 μm diam; abundant thin-walled inflated cells, elongate to 79 × 23 μm, subpyriform to very broadly clavate to 59 × 32 μm, ovoid to 92 × 48 μm; branching oleiferous hyphae present, 4.0 - 10.2 μm diam. LAMELLA TRAMA: bilateral; inflated cells arise at acute angles to distinct central stratum; undifferentiated filamentous branching hyphae 2.1 - 9.8 μm diam; inflated cells elongate to 75 × 24 μm, but mostly half those dimensions or less; oleiferous hyphae common to plentiful, 4.0 - 10.5 μm diam. SUBHYMENIUM: cellular (pseudoparenchymatous); basidia arise from globose to subglobose to pyriform cells of varying size (to about 15 μm major diam) in ramifying chains, forming a layer 30 - 45 μm deep. BASIDIA: 4-sterigmate, thin-walled, 30 - 42 × 7.7 - 11.0 μm; no clamps seen. UNIVERSAL VEIL: On pileus adjacent to pileipellis: gelatinizing undifferentiated filamentous branching interwoven hyphae plentiful. On pileus other than near pileipellis: without clear arrangement of structures; filamentous undifferentiated branching hyphae plentiful, 1.8 - 10.5 μm diam, rather frequently septate—especially near terminal inflated cells; inflated cells terminal, dominating, globose to subglobose to broadly pyriform to 66 × 63 μm, clavate to ellipsoid to 75 × 56 μm, with walls 0.5 - 1.0 μm thick; oleiferous hyphae plentiful, 2.8 - 12.6 μm diam. On stipe base: undifferentiated filamentous branching hyphae 1.7 - 6.3

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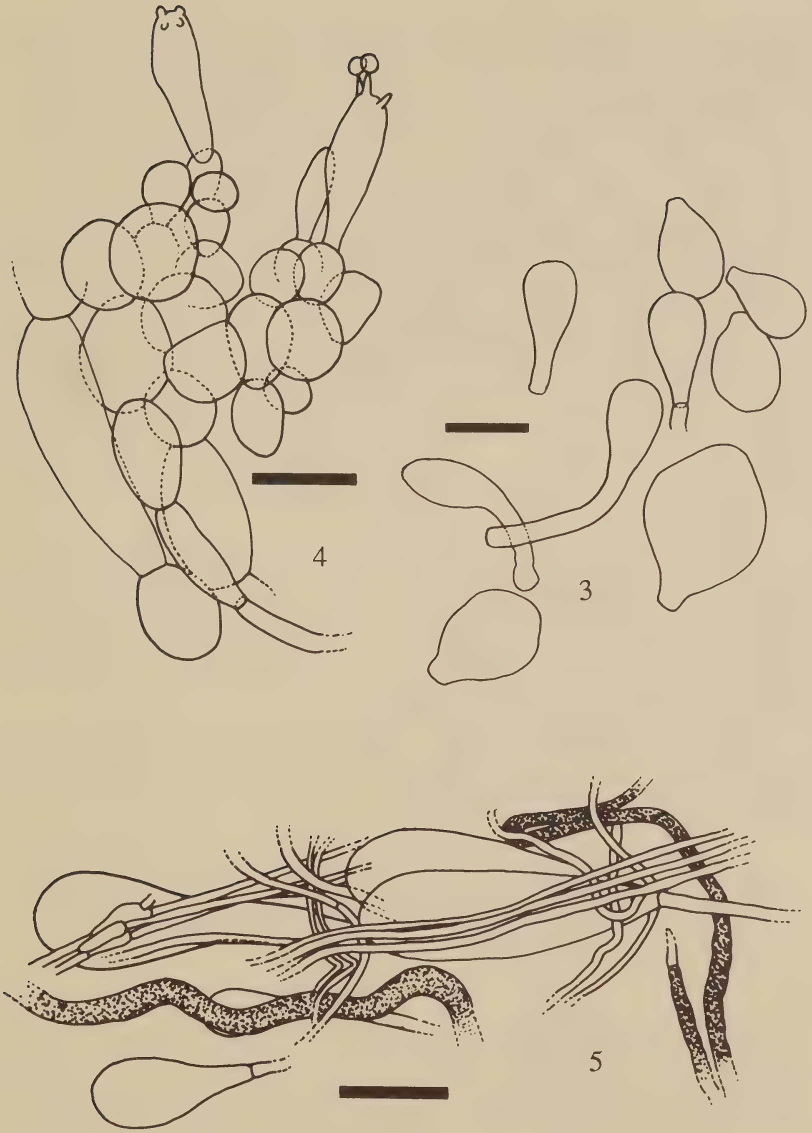
[2] Color designations in quotation marks are from Kornerup & Wanscher (1978). All others are mine.



Figs. 3-5 *Amanita salmonescens*. 3. Dissociated inflated cells from upper surface of the partial veil (King & Tulloss 7-16-83-D). 4. Elements of hymenium and subhymenium (King & Tulloss 7-16-83-A). 5. Partial veil elements (King & Tulloss 7-16-83-A). In Figs. 3-6: the dark bars represent 20 µm; stippling indicates oleiferous hyphae.

μm diam, about equally plentiful to inflated cells; inflated cells globose, subglobose, broadly ellipsoid, ellipsoid, cylindrical, clavate, up to 70 × 60 μm, terminal or in short chains; no clamps seen. STIPE CONTEXT: acrophysalidic; undifferentiated filamentous branching hyphae 1.0 - 11.5 μm diam; acrophysalides narrow, subcylindric to subfusiform to clavate, up to 156 × 47 μm, many less than half this diameter, some with thin-walls, many with walls 0.8 - 1.0 μm thick, some with basal septa to 14 μm diam because of slightly inflated subterminal cells; oleiferous hyphae common, but sometimes difficult to discern because they are rather narrow (4.2 - 7.0 μm diam) and mostly longitudinally arranged and infrequently branching, no coiling or curving segments seen; no clamps seen. PARTIAL VEIL: Below upper surface, branching filamentous undifferentiated hyphae predominant, 1.4 - 5.2 μm diam, interwoven; inflated cells terminal, clavate to broadly clavate, up to 119 × 35 μm, thin-walled; oleiferous hyphae common, irregularly arranged, locally dense and coiled in loose knots, occasionally branching, 2.0 - 11.0 (-18.0) μm diam; many filamentous hyphae and inflated cells have a common, subradial orientation. Upper surface has a predominance of rounder smaller dissociated cells, pyriform to broadly clavate as well as narrower clavate cells to 44 × 31 μm mixed with plentiful dissociated partially gelatinizing fragments of undifferentiated filamentous branching hyphae and plentiful oleiferous hyphae. All tissues pale yellow as reinflated in 10% NH_4OH.

BASIDIOSPORES: [105 from 4 specimens] (5.9-) 6.6 - 9.1 (-10.5) × (4.2-) 4.5 - 5.9 (-6.3) μm, (average length (per specimen) = 7.7 - 8.4 μm; average length (all specimens) = 8.1 μm; average breadth (per specimen) = 4.9 - 5.4 μm; average breadth (all specimens) = 5.2 μm; Q = (1.18-) 1.30 - 1.78 (-1.88); average Q (per specimen) = 1.45 - 1.62; average Q (all specimens) = 1.56), thin walled, hyaline, smooth, amyloid, broadly ellipsoid to ellipsoid to elongate, occasionally expanded at one end; contents guttulate; apiculus sublateral, cylindric; white in deposit.

Habitat and distribution: Solitary to subgregarious in red clay or in loam under deciduous trees including *Quercus spp.*, *Liriodendron tulipifera* L., *Acer sp.*, *Cornus florida* L., *Fraxinus sp.*, etc. and in mixed woods with similar trees and *Pinus spp.*, July to September, central New Jersey to western South Carolina.

Collections examined: NEW JERSEY, Mercer County, Princeton, Herrontown Woods County Park, New Jersey Mycological Association foray member 9-18-83-B; SOUTH CAROLINA, Oconee Co., Sumter National Forest, Stumphouse Tunnel Pk., M. A. King & R. E. Tulloss 7-16-83-A (holotype, NY), 7-16-83-D, 7-16-83-E.

DISCUSSION

The group of North American species of *Amanita* that appear "to be intermediate between sections *Validae* and *Lepidella*" were first noted by Jenkins (1983) in the description of *A. media* Jenkins. Jenkins (1984) again noted that there was some blurring of definition between the two sections in his description of *A. radiata* Jenkins. In both these cases, the mushrooms involved exhibited subcylindric to cylindric spores, had partial veils that tended to disappear rapidly after expansion of the basidiocarp, and had nonappendiculate pileus margins.

In the case of *A. salmonescens* different characters combine to produce the impression of a species at the border of sections *Validae* and *Lepidella*. In stature, occasionally finely appendiculate margin, form of the basal bulb and color, *A. salmonescens* resembles some white or pale-colored taxa of section *Lepidella*. The spores, sparseness of the appendiculate material on the pileus margin, and relatively persistent partial veil suggest section *Validae*. C. Bas (priv. corresp.) suggests that the cellular subhymenium of *A. salmonescens* should be considered to support placement in section *Validae*.

Amanita media differs from *A. salmonescens* in having average Q = 2.12, having many fewer inflated cells in the partial veil in relation to the quantity of undifferentiated hyphae, and not exhibiting the marked pinkish discoloration of stipe and partial veil (Jenkins, 1983). *Amanita radiata* is the other North American species described to date as being in section *Validae*, but carrying many of the properties of species in section *Lepidella*. *Amanita radiata* is distinguished from *A. salmonescens* by having a rapidly fugacious annulus, a brown to yellowish-brown pileus with pigment arranged in apparent radial fibrils, and an average Q = 1.93—among other characters (Jenkins, 1984).

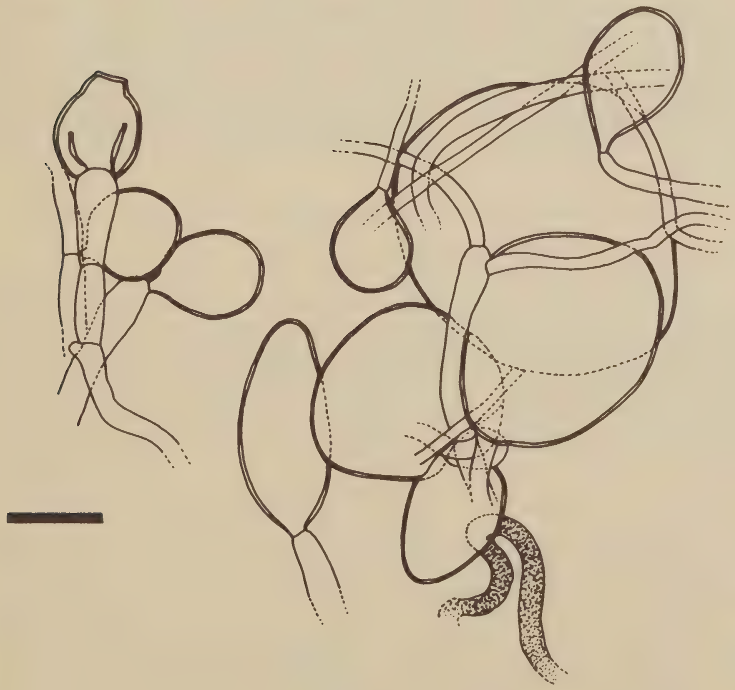


Fig. 6 *Amanita salmonescens*. Universal veil elements from wart on pileus (King & Tulloss 7-16-83-A).

One member of section *Validae* in North America is white and shows reddish or reddish-brown discoloration: *Amanita rubescens* var. *alba* Coker. It occurs in a range which overlaps the known range of *A. salmonescens*; it can be distinguished from the latter by having a subcellular to inflated ramose subhymenium, larger inflated cells in the universal veil, larger acrophysalides in the stipe context, slower and darker and more red-brown staining of the stipe, irregular and floccose warts, and generally broader spores having and average Q of 1.35 (Jenkins, 1986).

In section *Lepidella*, there are two North American species that bear comparison to *A. salmonescens*. *Amanita nitida* sensu Coker was described as having a pinkish-gray context (Coker, 1917). Bas (1969) examined Coker's collection and described the spores as follows: (20 from 1 specimen) 10.0 - 14.5 × 5.5 - 7 (-7.5) µm (Q = 1.6 - 2.5; average Q ≈ 2.0). The spores of *A. salmonescens* are consistently shorter than those of *A. nitida* sensu Coker; and the differences between this taxon and *A. salmonescens* in range of Q and average Q are marked. Moreover, *A. nitida* sensu Coker has a universal veil which, in the remains on the pileus, exhibits a structure dominated by vertically aligned chains of slightly inflated cells with larger, rounded cells less common than in *A. salmonescens*.

Amanita canescens Jenkins exhibits pinkish-orange fibrils near the base of the stipe, but differs in having a grayish-brown pileus (at least in disk), slightly longer spores with an average Q of 1.66, and a thick white annulus which does not change color and frequently falls away because it is dominated by inflated cells rather than hyphae as in *A. salmonescens* (Jenkins, 1986). Jenkins (1986) notes that the subhymenium of *A. canescens* is inflated ramose to subcellular, another character distinguishing it from *A. salmonescens*.

Amanita salmonescens is the entity I have called ''species 8'' in correspondence.

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ADDITIONS TO THE LICHEN FLORA OF ICELAND

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SUMMARY

Eleven species of lichens are reported as additions to the known lichen flora of Iceland, viz. Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold, Caloplaca crenularia (With.) Laundon, C. fraudans (Th. Fr.) Oliv., Epilichen scabrosus (Ach.) Clem. ex Hafellner, Lecanora contractula Nyl., Lecidea nigroleprosa (Vain.) H. Magn., Phylliscum demangeonii (Moug. & Mont. in Mont.) Nyl., Rhizocarpon geminatum Koerber, R. lavatum (Fr.) Hazsl., Stereocaulon arenarium (Sav.) Lamb. and S. symphycheilum Lamb. Information is provided concerning the taxonomy and ecology of the species.

INTRODUCTION

In his "Preliminary list of Icelandic lichens" Kristinsson (1984) enumerates about 550 lichen taxa known so far from Iceland. Apart from Epilichen scabrosus that is stated in the list without locality, none of the eleven species dealt with in the present paper is found in the list. Two species, viz. Lecanora contractula and Rhizocarpon geminatum, are mentioned in the thesis work of Baldursdóttir (1985).

The results presented here are based upon a study of collections made by the present author in June and July 1984 in connection with his sociological investigation of Iceland lichens.

The localities, where collections of lichens were made in 1984, are indicated on the map (Fig. 1).

Locality 1. Fagurhólsmýri (63°53'N 16°40'W).
Locality 2. Reykjavík (64°09'N 21°50'W).
Locality 3. Höfn (64°15'N 15°14'W).
Locality 4. Þingvellir (64°16'N 21°07'W).
Locality 5. Bifröst (64°46'N 21°33'W).
Locality 6. Blönduós (65°40'N 20°16'W).
Locality 7. Reykjahlíd (65°40'N 16°55'W).
Locality 8. Akureyrí (65°42'N 18°10'W).

LIST OF SPECIES

The following eleven species are here reported as new to Iceland:

Aspicilia caesiocinerea (Nyl. ex Malbr.) Arnold

The thallus of this microlichen is more or less bluish grey, rather thick and chinky-areolate with angular areoles that are either plane or concave (to verruciform). It reacts K- (sometimes K+ faintly brown). The apothecia are single or up to four in the areoles. The spores are often badly developed.

Typically A. caesiocinerea occurs on the top and somewhat sloping surfaces of manured, basaltic rocks together with, e.g., Candelariella vitellina (Hoffm.) Müll. Arg., Lecanora muralis (Schreber) Rabenh., Protoparmelia badia (Hoffm.) Hafellner and Xanthoria elegans (Link) Th. Fr. At Bifröst it grows on temporarily moist rocks in association with Porpidia flavocaerulescens (Hornem.) Hertel & Schwab, P. pseudomelinodes Schwab and Tremolecia atrata (Ach.) Hertel. A. caesiocinerea has previously been reported as new to the Faroes by E. S. Hansen & Fosaa (1985) and to West Greenland by E. S. Hansen (1986).

Specimens examined: Fagurhólsmýri, 1984 Hansen 84333 & 84834 (C). - Reykjavík, 1984 Hansen 84017, 84041 & 84075 (C). - Höfn, 1984 Hansen 84799 (C). - Bifröst, 1984 Hansen 84645 & 84877 (C). - Blönduós, 1984 Hansen 84176 (C).

Caloplaca crenularia (With.) Laundon

The thallus of the present specimens is thin, pale yellowish brown. The apothecia are up to 1 mm broad; the margin is subshining, entire or becoming crenulate; at first the disc is flat, later on it becomes convex. Its colour ranges from red rusty to rusty brown.

C. crenularia was collected in two localities, only, but presumably the species is more common in Iceland than indicated by the three specimens. At Þingvellir it was found growing on lava, while it occurs on basaltic rocks at Höfn. This agrees well with its ecological preferences in, e.g., England and Denmark: maritime xeric-supralittoral and inland, on neutral to basic rock (Pentecost 1987; Hansen 1987).

Specimens examined: Þingvellir, 1984 Hansen 84144 & 84257 (C). - Höfn, 1984 Hansen 84801 (C).

Caloplaca fraudans (Th. Fr.) Oliv.

The apothecia of the present specimen are up to 0.5 mm broad; the margin is thick, prominent, orange and more or less shiny; the disc is flat, brownish orange. The thallus is almost invisible.

C. fraudans was found growing on a basaltic bird rock. In Greenland the species preferably grows on manured, siliceous

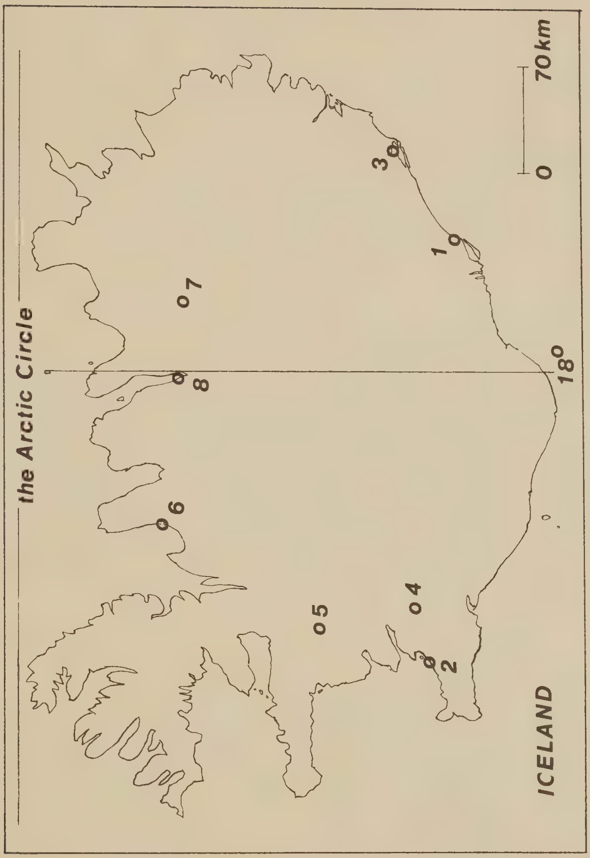
the Arctic Circle
ICELAND
0
70km
18°
1
2
3
4
5
6
7
8

Fig. 1. Location of the eight collecting sites in Iceland.

rocks (Hansen, Poelt & Søchting 1987).

Specimen examined: Blönduós, 1984 Hansen 84450 (C).

Epilichen scabrosus (Ach.) Clem. ex Hafellner

The collection consists of a single, small, greenish yellow thallus growing parasitically on Baeomyces placophyllus Ach. (cf. Alstrup & Hawksworth 1990). More or less confluent, slightly convex apothecia are present. The spores are well developed, brownish, two-celled.

E. scabrosus was found growing on an E.-exposed slope facing the sea on the outskirts of Reykjavík. The species is widely distributed in Northern and Western Europe. Hansen & Fosaa (1985) reported on its occurrence on the Faroe Islands.

Specimen examined: Reykjavík, 1984 Hansen 84010 (C).

Lecanora contractula Nyl.

This species forms scattered, up to 3 mm broad, pale grey thalli with densily clustered apothecia. The apothecia are up to 0.8 mm broad with a dark brown to greyish black disc.

L. contractula was found growing on seashore rocks composed of basalt and manured by birds near Blönduós in northern Iceland. Baldursdóttir (1985, unpublished master of science thesis) mentions the species from four additional localities, viz. Brautarholt, Stykkishólmur, Vestrahorn and Hrísey. It is also known from Greenland, northern Norway and Kola Peninsula (Poelt 1983).

Specimen examined: Blönduós, 1984 Hansen 84178 (C).

Lecidea nigroleprosa (Vain.) H. Magn.

The thallus of this species is lead-coloured and areolate. The areoles are flat to convex, occurring on a black hypothallus and breaking up into black soralia. The apothecia are up to 1 mm broad with a thin and disappearing margin. The epihymenium is greenish.

L. nigroleprosa was found only in one locality situated in western Iceland. Here it grows on the top of a basaltic rock in an area otherwise dominated by lava in association with, e.g., Porpidia pseudomelinodes, Tremolecia atrata, Lecanora intricata (Ach.) Ach. and L. polytropa (Hoffm.) Rabenh. Recently L. nigroleprosa has been reported from Greenland (Hansen 1983). It grows on gneissic and basaltic rocks on Disko Island.

Specimen examined: Bifröst, 1984 Hansen 84874 (C).

Phylliscum demangeonii (Moug. & Mont. in Mont.) Nyl.

The thallus of this rather inconspicuous lichen forms somewhat incised, black rosettes, less than 5 mm in diameter. It is firmly attached to the rock. The apothecia are immersed in the thallus forming small warts with a punctiform opening.

The species was found at Þingvellir on a SE.-exposed face of a basaltic rock near a watercourse. It occurs more or less scattered in Scandinavia, Greenland and the Alps (Poelt 1969; Hansen 1984).

Specimen examined: Þingvellir, 1984 Hansen 84147 (C).

Rhizocarpon geminatum Koerber

The thallus of this crustaceous lichen is similar to that of Rhizocarpon disporum (Naeg. ex Hepp) Müll. Arg., i.e., it is composed of grey, rounded verrucules distributed on a black hypothallus. An important diagnostic character is the number of spores per ascus: two (the asci of R. disporum are one-spored). The Iceland material of R. geminatum is richly fertile.

Most of the present specimens of R. geminatum are from inland localities, where the species occurs on sunny, often vertical surfaces of basaltic rocks impregnated by nutritious dust. It grows on lava at Reykjahlíd near Mývatn. At Blönduós and Höfn R. geminatum occurs on seashore rocks composed of basalt and influenced by guano. Here it is associated with Xanthoria elegans and Aspicilia caesiocinerea, whereas it occurs together with, e.g., Xanthoria parietina (L.) Th. Fr., Ochrolechia parella (L.) Massal. and Acarospora smaragdula (Wahlenb.) Massal. on some other localities. In her master of science thesis Baldursdóttir (1985) reports on the occurrence of R. geminatum at four localities, viz. Brautarholt, Stykkishólmur, Hrísey and Kolmúli. On the lava blocks at Reykjahlíd R. geminatum is associated with Xanthoria elegans, X. candelaria (L.) Th. Fr., Physcia caesia (Hoffm.) Fürnr., Lecanora muralis, Rhizocarpon geographicum (L.) DC. and Lecanora polytropa. A similar association was previously found by the present author on a large bird rock at Iterdlak near the head of the inlet Tunugdliarfik in South West Greenland, in an area that is also characterized by a relatively dry and summerwarm climate (Hansen 1978). R. geminatum is widely distributed in the mountainous parts of Europe (Poelt & Vězda 1981).

Specimens examined: Höfn, 1984 Hansen 84190 (C). - Þingvellir, 1984 Hansen 84141, 84249, 84259 & 84349 (C). - Blönduós, 1984 Hansen 84162 & 84176 (C). - Reykjahlíd, 1984 Hansen 84220, 84275 & 84749 (C). - Akureyrí, 1984 Hansen 84513 (C).

Rhizocarpon lavatum (Fr.) Hazsl.

The thallus of the present specimens is greyish to rust-red, chinky-areolate with thick, flat areoles. The apothecia are up to 1 mm broad, brownish black with a rust-red tinge. The margin is thick. A central umbo is found on a few apothecia. The asci contain eight, hyaline, muriform spores.

The two specimens of R. lavatum were found on manured, basaltic stones in the eastern part of Reykjavík near the sea. Hansen & Fosaa (1985) reported the species as an addition to the lichen flora of the Faroes. So far it is not known from Greenland.

Specimens examined: Reykjavík, 1984 Hansen 84021 & 84033 (C).

Stereocaulon arenarium (Sav.) Lamb

The pseudopodetia of this species form dense tufts that are firmly attached to the soil substrate. They are up to 2 cm tall and simple to slightly branched with a dead and bare basal part. Tomentum is present on the upper part of the pseudopodetia. The phyllocladia are more or less peltate and similar to those of S. vesuvianum Pers. Brownish cephalodia occur abundantly between the phyllocladia. The present plants are sterile. The thallus reacts K+ yellow and P+ faintly yellow.

All of the three collections are from plains covered by basaltic stones and lava blocks in the alpine zone of Iceland. Here S. arenarium grows on gravelly soil among the stones together with, e.g., Stereocaulon alpinum Laur. Thomson (1984) refers the species to the group of Amphi-Beringian species. It is known from Greenland, Arctic North America and Kamtchatka. Hansen & Vestergaard (1979) previously reported S. arenarium from four localities on Jan Mayen.

Specimens examined: Fagurhólsmýri, 1984 Hansen 84197 & 84602 (C). - Blönduós, 1984 Hansen 84788 (C). - Akureyrí, 1984 Hansen 84419 (C).

Stereocaulon symphycheilum Lamb

The present collection of S. symphycheilum consists of about twenty pseudopodetia that are distinctly dorsiventral, prostrate and up to 15 mm tall. They are either simple or somewhat branched without a tomentum. Capitate soralia are present. The phyllocladia are confluent and peltate with a thicker margin of paler colour and thus comparable to those of S. vesuvianum. Brown cephalodia containing Stigonema-algae occur abundantly. The Iceland specimens are sterile. Thallus reacts K+ yellow and P+ yellow.

S. symphycheilum was collected in one locality in south-eastern Iceland, firmly attached to a fragment of lava. The species has previously been reported from Scandinavia, Kamtchatka and North America (Lamb 1977).

Specimen examined: Fagurhólsmýri, 1984 Hansen 84326 (C).

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METHODS FOR ISOLATION OF CANTHARELLUS SPECIES, AND THE SYNTHESIS OF ECTOMYCORRHIZAE WITH PICEA ABIES

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Summary

During 1988, 56 strains of Cantharellus cibarius and 4 strains of C.pallens were isolated from tissues of fruitbodies. In 1989, artificial ectomycorrhizae with C.cibarius and Picea abies were formed. The only strain of C.cibarius that formed mycorrhizae with P.abies was isolated from a fruitbody associated to this tree. The Hartig net involved the entire cortex, which implies a complete colonization.

Introduction

The edible ectomycorrhizal basidiomycete Cantharellus cibarius Fr. has been difficult to isolate (Danielson 1984, Froidevaux 1975, Modess 1941), mainly due to the presence of bacteria in the tissues of the fruitbody (Straatsma et al. 1985, Itävaara & Willberg 1988). Fries (1979) has developed a method for germination of the spores of C.cibarius, but for mycorrhizal synthesis, mycelia from tissues are preferred because they have completed the life cycle at least once. The technique for isolation of C.cibarius mycelia from tissues was described by Straatsma (1985), but has been unsuccessfully tried elsewhere (Itävaara & Willberg 1988). Moore et al. (1989) have synthesized mycorrhizae with C.cibarius and Pinus sylvestris L. and Betula pubescens Ehrh.

The purpose of this study was to isolate Cantharellus species, and to elucidate the conditions for ectomycorrhizal formation. This investigation may lead to experimental methods for solving taxonomical problems in the genus Cantharellus, as well as being a step towards the control of the life cycle of C.cibarius.

Methods for isolation of mycelia

Between July 21 and October 4 1988, 229 fruitbodies of C.cibarius were collected. They represented at least 70 clones from 13 coniferous forests in the province of Uppland, Sweden. Eight fruitbodies of Cantharellus pallens Pilat and ten of Cantharellus tubaeformis (Bull.:Fr.) were collected. Under sterile conditions, $5mm^3$samples from the inside of the fruitbody were transferred to 9cm Petri dishes. In these, one of the following sterile filtered media was used in 1.2% Bactoagar:

1. Murashige & Skoog medium at pH 4.2 (Straatsma et al. 1986), antibiotics (50 ppm streptomycin and ampicillin and 5 ppm benomyl) and 0.05% activated charcoal.

2. Modified Fries medium at pH 5.5 (Straatsma & Bruinsma 1986), and a thin layer of activated charcoal on the surface of the agar gel.

3. Modified Fries medium with C-elements (Straatsma & Bruinsma 1986) to compensate the CO_2 requirement. Antibiotics and activated charcoal as in 1 and 2.

A reference mycelium of Suillus luteus (L.:Fr.) S.F.Gray was inoculated on the same types of media.

The Petri dishes were incubated in darkness at 20°C. Peripheral hyphae were reinoculated until sterile. Sterile mycelia were grown on modified Fries medium with or without C-elements, and on 2% malt agar with Fries medium. The radial growth rate of a colony was measured after two months.

Spores of C.cibarius and C.tubaeformis were spread out on agar with modified Fries medium in order to get polysporous mycelia.

Methods for mycorrhizal synthesis

Seeds of Picea abies (L.:Karst.) were sterilised with 70% EtOH for 30s, then with 30% H_2O_2 for 20 minutes. After washing in sterile distilled water, they were transferred to Petri dishes with 1.2% Bactoagar and incubated in 20°C and 30000 lux.

Two main methods for mycorrhizal synthesis were used. The first is based on Unestam & Stenström (1989). Petri dishes (14cm) were filled with unsterile perlite or brick pellets (Leca) and peat 3:1 (v/v). A hole for the 1-3 weeks old plant was made at the edge of the dish, and the roots were spread out on the substrate. Washed pieces of agar mycelia were used as inocula. The dishes were vertically incubated in a small greenhouse at 22-24°C and 65-85% relative humidity with 21 hrs daylight 30000 lux (Osram 125W HQL-R). The plants were watered with Ingestad nutrient solution (1979). Totally, 32 dishes with perlite and 16 with Leca/peat were used. Six strains of *C.cibarius* were tested.

The second method implied the use of sterile test tubes 25x200 mm with 20 ml perlite. Between January 3 and July 10, 1989, 140 test tubes were inoculated with suspensions of hyphae from 15 strains of *C.cibarius*. Agar mycelia were transferred to liquid Fries medium and incubated for 4-8 weeks. The colonies were then fragmented in 100 ml Erlenmeyer flasks with glass beads and fresh modified Fries medium. The suspension was filtered (pore size 1mm) and 7 ml was added to each tube. Young seedlings of *Picea abies* were planted, and the tubes were sealed with Nesco film. Incubation as described above. Fifty other tubes were inoculated with agar mycelia. Ten different strains of *C.cibarius* were used. Modified Fries medium (7ml) was added together with 1-3 weeks old plants of *Picea abies*. The tubes were sealed with Nesco film, and incubated as in the first method.

Methods for studies of mycorrhizae

The Hartig net, which is the pattern of hyphae penetrating between the cortex cells of the root, is the criterium of the ectomycorrhizal double organism (Harley & Smith 1983).

Therefore, in order to study if there were pseudomycorrhizae or true mycorrhizae with Hartig net, short roots with mantles of hyphae were fixed in 2.5% glutaric aldehyde before cutting. Mycorrhizae and one uninfected short root were later fixed in $KMnO_4$ or OsO_4, embedded in epon, cut (30 nm) and stained with UAc and Pb for TEM. Another mycorrhiza was dehydrated with EtOH, embedded in 2% agar, infiltrated with GMA (Historesin LKB2218-500), cut (3-5 μ) and finally stained with methylene blue or safranin 1%. Mycelia from the synthesis were reinoculated on modified Fries medium.

Results of field observations

Fruitbodies of *C.cibarius* were found in different biotopes in 1988. Several rocky localities with *Pinus sylvestris* were rich in fruitbodies among lichens (*Cladina*) and in crevices of rocks. In mixed forests of mainly *Picea abies*, *C.cibarius* is common among *Vaccinium myrtillus* L., mosses (*Pleurozium*, *Hylocomium*, *Ptilium* and *Polytrichum*) and grass (*Calamagrostis*). Occasional findings were made in wet biotopes among *Mnium* moss, but never with *Sphagnum* moss. Potential host trees are *Picea abies*, *Pinus sylvestris*, *Betula pendula* Roth. and *Quercus robur* L. *C.cibarius* is presumed to have a broad spectrum of hosts (Schenk 1984). *C.pallens* was only found close to *Corylus avellana* L.

Results of isolations of mycelia

With Murashige & Skoog medium, 56 strains of C.cibarius were isolated. Growth did not occur before a 17-53 days long lag period ($\bar{x}$=35d). 100% of the fruitbodies were naturally infected by bacteria, but 24% of the mycelia grew out from the infection zone. Four strains of C.pallens were isolated.

All 36 tissue samples that were inoculated on modified Fries medium died due to fatal bacterial infections.

The growth rate of C.cibarius was 0.1-0.5 mm/d, depending on the age of the mycelium (lag phase), strain and pigment type. The growth rate of the reference S.luteus mycelium was 1.1 mm/d. Recently isolated mycelia of C.cibarius are yellow - yellow/white with thick hyphae and clamp connections. Yellow mycelia in the agar tend to form white mycelia around particles of activated charcoal on the agar surface. The mycelium of C.pallens is similar to that of C.cibarius. None of the isolated strains grew on malt agar, which the yellow ectomycorrhizal basidiomycete Piloderma croceum Erikss & Hjortst. does (Nylund & Unestam 1982).

A strain of C.cibarius can spontaneously change types of mycelia. One type grows slowly in the agar and is pigmented. The other type has a rapid growth, produces only little pigment and forms a loose aerial mycelium on the agar surface. By inoculating the unpigmented type to modified Fries medium with Tween 80, malic acid, MES and thymine, a heavy pigmented, compact and slowly growing agar mycelium was induced. According to Straatsma & Bruinsma 1986, these added "C-elements" compensate the demand for CO_2, which is necessary for production of pyrimidines and fatty acids. The pigmented type of mycelium can survive at least eight months in optimal environment, but growth is inhibited after about six weeks. After inoculation, the pigmented mycelium might change to the unpigmented type, which does not survive more than three months without reinoculation.

Spores of C.cibarius germinated after 6-12 weeks. Heterokaryotic mycelia from spores were similar to mycelia from tissues, and responded in the same way to malt agar and C-elements. Spores of C.tubaeformis germinated after ten months. The weak yellow mycelium grew rapidly in the agar and had clamp connections.

Results of mycorrhizal formation

With the unsterile method, no growth of mycelium was observed during ten months. The plants grew rapidly up to the lid (9cm), and the root systems were well developed with many short roots.

The growth of hyphae in tubes inoculated with agar mycelia was negligible. Suspensions of hyphae were better, but differed among the tested strains. The plant shoots had developed only 2cm after six months in tubes sealed with Nesco film. The roots did not branch easily, and formations of calli occurred occasionally. Out of 15 strains of C.cibarius cultivated in tubes, only SNGT2 formed ectomycorrhizae with Picea abies (Fig. 1). The first unramified mycorrhiza appeared after 5 months. The smooth mantle was yellow with hyphae emanating from the surface, but without rhizomorphs. The transections made after 9 months (Figs. 2-3) showed a 45-50 µm thick plectenchymatous mantle, and a deep Hartig net that was limited only by the endodermis (Fig. 4). Reinoculated mycelia from the synthesis were not contaminated.

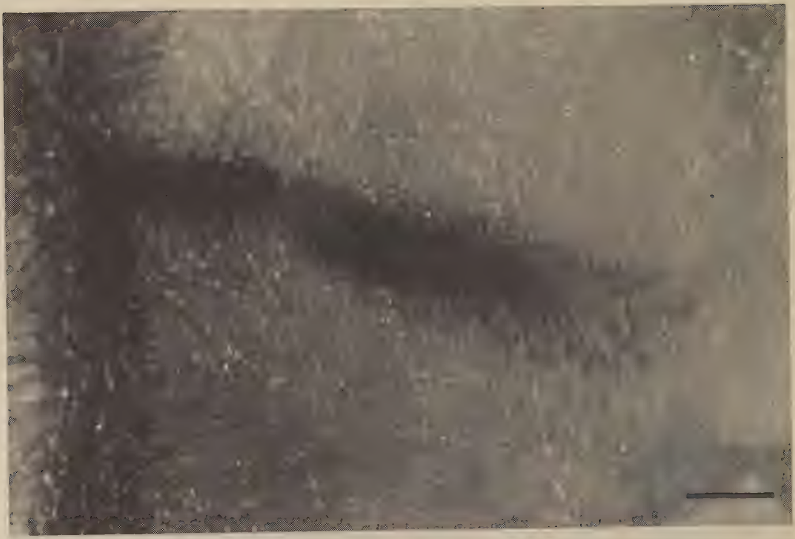
Discussion

The switch from slow growth and pigment production to rapid growth and more aerial mycelium might be a way for the fungus to reach CO_2. In presence of the C-elements, growth is not acute, and the mycelium can grow into the nutrient agar.

C.cibarius did not grow in the unsterile system described by Stenström & Unestam (1989). The uncontrolled irrigation with momentary or longer flooding might cause gas shortage that affects sensitive species. This was also observed by Stenström & Unestam (1989).

For mycorrhizal formation in sterile tubes, C.cibarius requires a long period of incubation due to the slow growth. Since the sealing film reacts on the atmospheric pressure, the gas exchange is apparently insufficient, and therefore only a few mycorrhizae were formed.

The thickness of the mantle is probably a result of the addition of sugars in the tube. The Hartig net with Pinus sylvestris and B.pubescens described by Moore et al. (1989) was only 1-2 cell layers deep, but in our experiment with Picea abies, the Hartig net involved the entire cortex. This difference is perhaps due to the shorter period of development in the first case (4.5 months vs 9 months). However, the age of our mycorrhizae varied at the time of sectioning, i.e. some had developed later than the first observed mycorrhiza. It could also be that the mycelium of Moore et al. (1989), found with Q.robur, is less successful when colonizing other species. In our case the strain SNGT2 was isolated from a fruitbody associated with Picea abies, and also reinfected that species artificially. The other 14 strains were found with Pinus sylvestris or had an unidentified host. Maybe there are strains of C.cibarius that are adapted to certain hosts, in contrast to the conclusions of Moore et al. (1989). Differences in the physical and chemical environments of the two experiments are also to be considered.



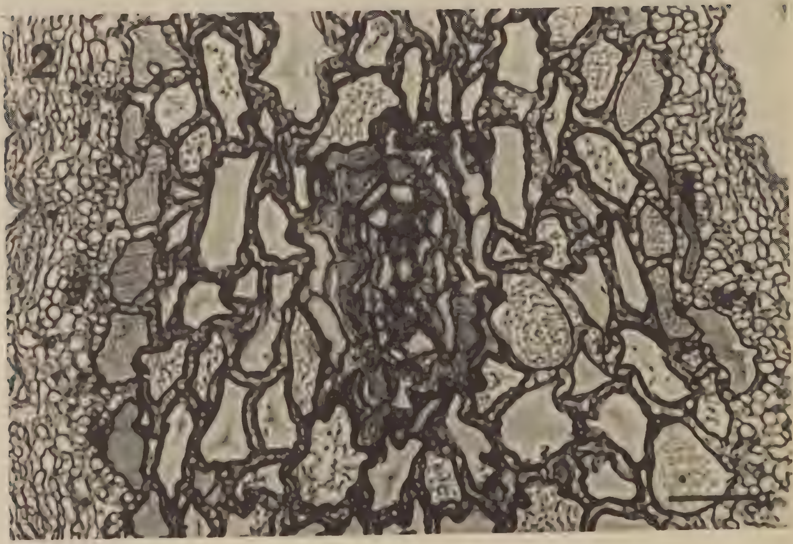
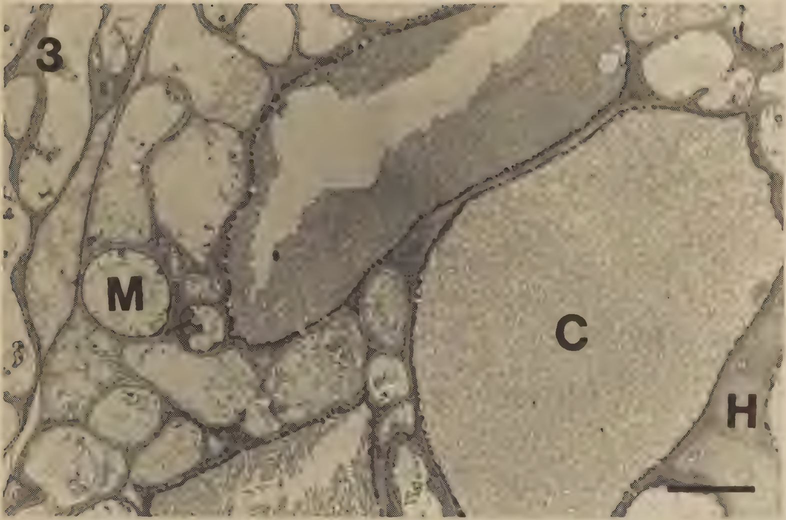


Fig. 1. Mycorrhiza of Cantharellus cibarius SNGT2 and Picea abies. The bar length indicates 0.4 mm.

Fig. 2. Transection of the mycorrhiza, showing mantle, Hartig net and stele. The bar length indicates 30 µm.



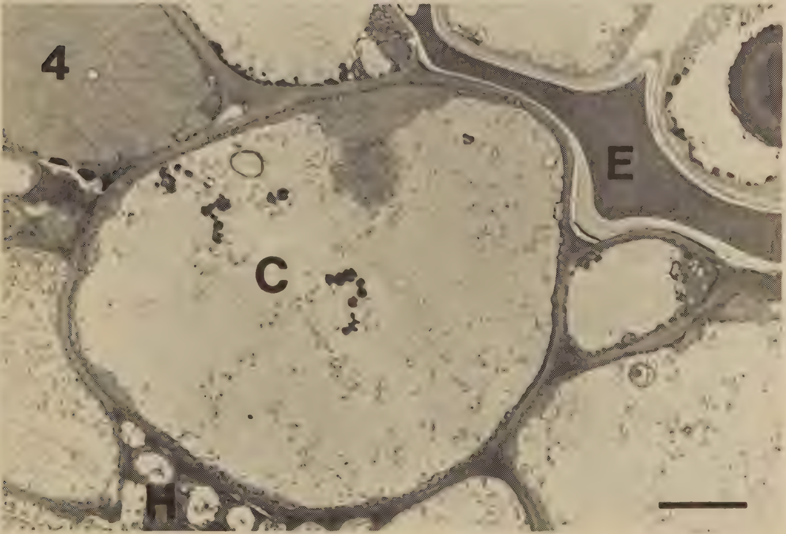


Fig. 3. TEM-photograph of a mycorrhiza of Cantharellus cibarius SNGT2 and Picea abies. M=mantle hypha, C=cortex cell, H=Hartig net hypha. The bar length indicates 6 µm.

Fig. 4. The same mycorrhiza and magnification as fig. 3. E=endodermis.

Acknowledgements

We thank Lynn Moore and her colleagues for discussions and encouragement in all ways. Thanks are also due to the Department of Forest Mycology and Pathology, the Swedish University of Agricultural Sciences, for valuable discussions and assistance with mycorrhizal analyses. Mrs Annette Axén kindly performed the TEM at our department. Financial support came from the Foundations of Anders Wall.

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THE HYPHOMYCETE GENUS GOIDANICHIELLA

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Goidanichiella was introduced by Barron for a Hyphomycete with slimy phialoconidia borne in *Aspergillus*-like heads, to replace *Goidanichia* Arnaud, nom. inval. et illeg., which was found to be congeneric with *Haplographium*. All comparable genera are briefly reviewed. Barron's material and some recent isolates turned out to belong to a single species, *G. barronii*, which is remarkable by its dimorphic conidia. During degeneration of the isolates, formation of subglobose conidia is progressively suppressed and only allantoid conidia are formed on more slender and irregularly shaped conidiophores.

The genera *Gliocephalis* Matruchot (1899) and *Goidanichiella* "Arnaud ex Barron" (1968) seem to form a natural group of hyphomycetes with large, erect conidiophores ending in a capitulum of metulae and phialides. Contrary to the *Aspergillus* anamorphs of the Trichocomaceae, the phialoconidia form large slimy masses. Species of these and similar genera are of rather rare occurrence in soil and only few, mostly imperfectly named, isolates are so far available in culture collections.

Gliocephalis, with the type species *Gl. hyalina* Matr., was originally described from roots of beetroot in France and redescribed by Arnaud (1952) from pine cones and twigs (no herbarium material preserved) and by Barron (1968) from a decaying potato tuber in Canada. Another, unnamed, species was described by Embree (1963) from potting soil in San Francisco. The conidiophore stipes of this genus are described as non-septate and hyaline, but in Embree's fungus they were pigmented and 1–2-septate and it might therefore belong to *Goidanichiella*. Unfortunately this isolate could not be perpetuated in pure culture either. It appears that *G. hyalina* can not be grown axenically without other contaminating fungi or bacteria. No living isolate could be found in any culture collection. An additional species, *G. pulchella* (Penzig & Sacc.) D. Hawksw. (syn. *Gliocladium pulchellum* Penzig & Sacc.), was described by Hawksworth (1979) as a lichenicolous Hyphomycete from type material collected in Java.

Goidanichiella as described by Barron (1968) differs from *Gliocephalis* by pigmented, septate conidiophore stipes. It was thought to be originally described by Arnaud (1953) for a single species listed as *G. scopula* (Goid.) Arnaud (with the basionym *Scopularia scopula* Goidánich, 1933), under the homonymous form of *Goidanichia* [non *Goidanichia* Tomaselli & Cif. 1952 (Lichenes)], but corrected in handwriting by Arnaud on some reprints to *Goidanichiella*, and without a Latin diagnosis; the genus was explicitly considered different from *Scopularia* Preuss. Arnaud's illustration shows dark conidiophore stipes, rather parallel metulae and conidiogenous cells (possibly phialides) and narrowly ellipsoidal conidia.

A somewhat different fungus with subglobose conidia was described by Barron (1968) as having phialidic conidiogenesis, again without Latin diagnosis of the genus, as *Goidanichiella* sp.. An additional species, *G. sphaerospora*, was described by Matsushima (1975), again without Latin diagnosis of the genus. Thus the genus is apparently still not valid (Carmichael *et al*., 1980).

Several isolates that seem to fit Barron's generic description have recently become available and prompted this study.

The available older names

Scopularia Preuss (1851), type species *S. venusta* Preuss (also illustrated in Preuss, 1862), is illegitimate being a homonym of *Scopularia* Lindley 1835 (Orchidaceae). It was found on decorticated pine wood and the illustration (reproduced by Kendrick, 1964) suggests its possible identity with *Haplographium*. Kendrick (1964) examined the type specimen preserved at B and found it to be in unrecognizable shape. Therefore, the name is of doubtful application. The genera *Lindavia* Nieuwland (1916) [a homonym of *Lindavia* (F. Schütt) de Toni & Forti 1900 (Diatoms)] and *Outhovia* Nieuwland (1916) have been proposed to replace it. The genus was subsequently often used in the sense of *Phialocephala* Kendrick (1961). This genus is not considered to be related to *Goidanichiella*, the conidiophores being darkly pigmented and much narrower.

Goidánich (1933) under *Scopularia scopula* illustrated a fungus with dark conidiophores, the wall of which bursts apically to give rise to three levels of branch cells and the conidiogenous cells taper to a point where the conidia are produced, given as 2.5—3.5 × 1—2 μm. The fungus was found on decaying wood of *Fraxinus ornus* (?) near Bologna. All this strongly suggests the identity with *Haplographium catenatum* (Preuss) Hol.-Jech. Unfortunately all the mycological material preserved at Bologna was destroyed during world war II (G. Govi, pers. comm.).

In Arnaud's herbarium (PC, Nicot & Charpentié, 1971) only one specimen (referring to plate 250) is preserved under the name *Goidanichia scopula*, but unfortunately this specimen, labelled as consisting of decaying bark, contains neither bark nor a single comparable conidiophore; apparently it has been confused at some time with different material. Arnaud's for the most part unpublished drawings (plates 250, 549 F—I, and 2163 K—L), however, unequivocally indicate the identity of this species with *Haplographium*, probably *H. catenatum* (Preuss) Hol.-Jech., the anamorph of *Hyaloscypha dematiicola* (Berk. & Br.) Nannf., thus quite a different fungus than the one to be described here.

Scopularia corsicana van Beyma (1944) is again a different fungus with rather short conidiophores and polyblastic conidiogenesis.

A further genus, *Gloiosphaera* Höhnel (1902), differs by several whorls of branches arising from the stipe cells in the apical region. The type species is *G. globuligera* Höhnel (1902) = *G. clerciana* (Boud.) Höhnel (1905). The fungus was found on decaying wood in Austria and the U.S.A. The conidiophore stipe is hyaline, roughened and densely septate. The species was illustrated by Wang (1971) and the genus was revised by Pollack & McKnight (1972). Attempts by these authors to grow *G. clerciana* in culture were not successful. *G. minor* Höhnel (1924) is a second species. *Scopula* Arnaud (1952, nom. inval.) is probably a synonym of the genus.

Another comparable genus is *Myxocephala* Weber *et al.* (1989), which differs from the above genera by penicillate branching of the conidiophore tips. *M. albida* was isolated from rootlets of *Picea abies*.

Thus *Scopularia* and its substitute names are not available for *Goidanichiella*. Barron (1968) was obviously the first to describe a species of *Goidanichiella* as a Hyphomycete with phialidic conidiogenesis. So far there are no other generic names competing with it and *Goidanichiella* sensu Barron can be validated here.

GOIDANICHIELLA Barron ex W. Gams, *gen. nov.*

Genus Hyphomycetum. Conidiophora erecta, lata, compluries septata, dilute brunnea, sursum in vesiculam fertilem exeuntia; vesiculae serie metularum obtectae e quibus nonnullae phialides oriuntur; metulae phialidesque hyalinae. Conidia unicellularia, mucida, hyalina.
Species typica: *Goidanichiella barronii* W. Gams, Steiman & Seigle-Murandi.

A genus of Hyphomycetes. Conidiophore stipes erect, wide, repeatedly septate, with rather pale brown pigmentation, ending in a fertile vesicle; the vesicle covered with a series of metulae, each bearing a number of phialides; metulae and phialides hyaline. Conidia one-celled, slimy, hyaline.

All the available material of *Goidanichiella* in this sense was found to represent a single, variable species.

Goidanichiella barronii W. Gams, Steiman & Seigle-Murandi, *sp. nov.* -- Figs. 1—3.

Goidanichiella sp. Barron, Genera of Hyphomycetes from Soil: 180. 1968.

Coloniae rapide crescentes, dilute griseae. Conidiophora copiosa sparsa, erecta; stipites dilute brunnei, 2—4(—6) septis divisi, 125—400 (—600) μm alti, prope basim (6—)8—13 μm lati, sursum ad 4—7.5 μm angustati et in vesiculam 11—20(—25) μm diam in parte superiore fertilem inflati. Metulae seu modice divergentes seu parallelae, 6.5—11 × 2—3.5 μm, 3—5 phialides compressas, sursum angustatas, 7.5—10 × 1.5—2.5 μm ferentes. Conidia in massa mucida acervata, seu subglobosa vel late ellipsoidea, fere crassitunicata, 3—4 × 2.0—3.0 μm, hyalina, levia, seu allantoidea, tenuitunicata, 4—6.5(—7) × 1.4—2.0 μm. Conidia subglobosa primum e capitulis divergentibus, allantoidea post tempus e capitulis parallelis oriuntur.

Typus CBS 101.89 = CMPG 426, isolatus e terra turbosa, St. Marcellin, Isère, in Gallia, 1979.

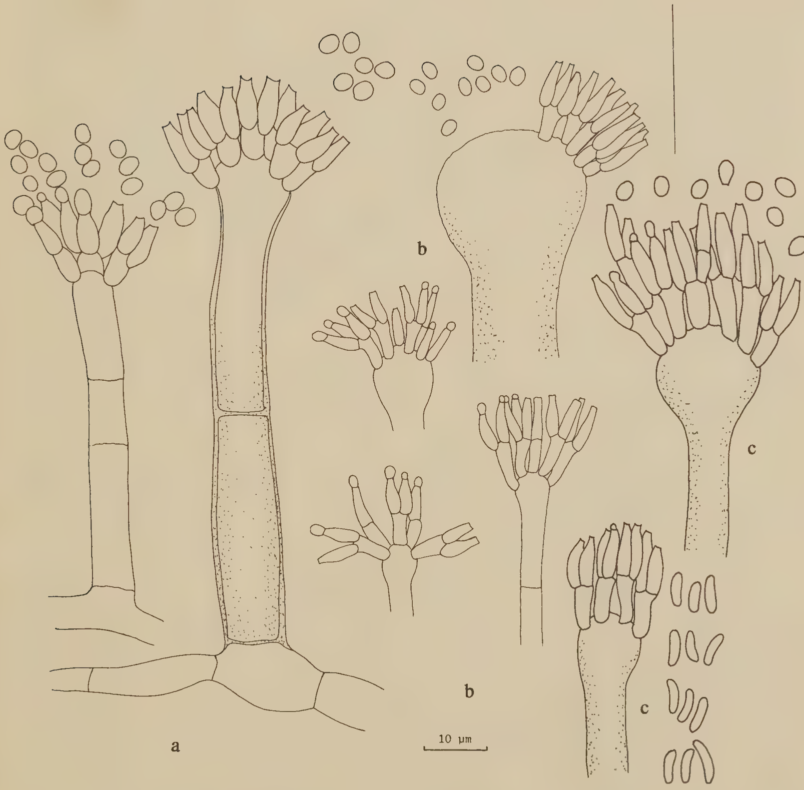

Fig. 1. *Goidanichiella barronii*, **conidiophores and subglobose conidia. a. CBS 101.89, b. Barron's slides, c. CBS 587.89 after preservation in liquid nitrogen.**

Colonies on MEA thin, at first hyaline, later becoming greyish, spreading broadly, with daily radial increments of 8—12 mm at 24—28°C. Conidiophores scattered, erect, stipes pale brown, 125—400(—600) μm high, (6—)8—13 μm wide near the base, tapering to 4—7.5 μm near the tip, with 2—4(—6) septa (including the one at the base), supported by a swollen cell in the subtending hypha, about 60—70 × 8—13 μm; at the tip ending in a fertile vesicle, sometimes with a slight constriction below the inflation; vesicle 11—20(—25) μm diam, fertile in the upper part, bearing a series of moderately divergent or strictly parallel metulae, 6.5—11 × 2—3.5 μm, each metula bearing 3—5 appressed tapering phialides, 7.5—10 × 1.5—2.5 μm (measured near the base). Metulae and phialides rapidly collapsing after maturity. Conidia cohering in large whitish slimy masses, either subglobose to broadly ellipsoid, rather thick-walled, 3—4 × 2.0—3.0 μm, or allantoid, thin-walled, 4—6.5 (—7) × 1.4—2.0 μm, both types hyaline, smooth-walled. The two kinds of conidia arise from separate conidiophores; the subglobose to broadly ellipsoid conidia seem to be the primary type, arising in fresh isolates from conidiophores with more or less divergent capitula; the allantoid conidia are formed on conidiophores with less pronounced vesicles and parallel metulae; for the rest the conidiophores of both types are indistinguishable.

Growth on PDA (potato-dextrose agar) slightly faster than on MEA.

Minimum temperature for growth about 10°C, optimum 22—28°C, maximum 33—36°C. No growth occurring on hyperosmotic medium (malt extract 5%, saccharose 3%, NaCl 8% w/w) used to reveal xerophilic fungi.

Some physiological tests were carried out in the course of a routine screening programme for lignin-degrading fungi (Steiman & Seigle-Murandi, 1984; Seigle-Murandi *et al.*, 1986; Rahouti *et al.*, 1989). Growth on phenolic compounds was tested on MEA and on synthetic medium (SM) without sugar but with 0.5 g substrate per litre as described previously (Steiman *et al.*, 1982). Results were negative on SM and MEA with phenol and catechol. MEA with guaiacol, protocatechuic, vanillic, ferulic and syringic acids gave normal colonies. Studies on the degradation of these lignin precursors in liquid synthetic medium were carried out as described previously (Seigle-Murandi *et al.*, 1986). The final concentration of phenolic compounds was 0.2 g/l and the cultures were grown at 22°C under shaking coniditions for 6 days. Consumption of phenolic compounds was tested by thin layer chromatography and high performance liquid chromatography with the following results: phenol 46%, catechol 6%, guaiacol 60%, protocatechuic acid 15%, vanillic acid 12%, ferulic acid 54%, syringic acid 22%. The fungus was also able to metabolize pentachlorophenol 20%.

The methods used for the detection of lipase, protease and amylase production have been described by Hankin & Anagnostakis (1975). Lipolytic activity was tested by using sorbitan monolaurate (Tween 20) as lipid source, proteolytic activity be utilization of gelatin, and amylolytic activity by utilization of soluble starch. Cellulases were detected according to Smith (1977); the same method was adapted for the detection of chitinases by using chitin-azur, prepared according to Rinderknecht *et al.* (1967). *G. barronii* was not found to be cellulolytic, lipolytic, amylolytic, proteolytic or chitinolytic.

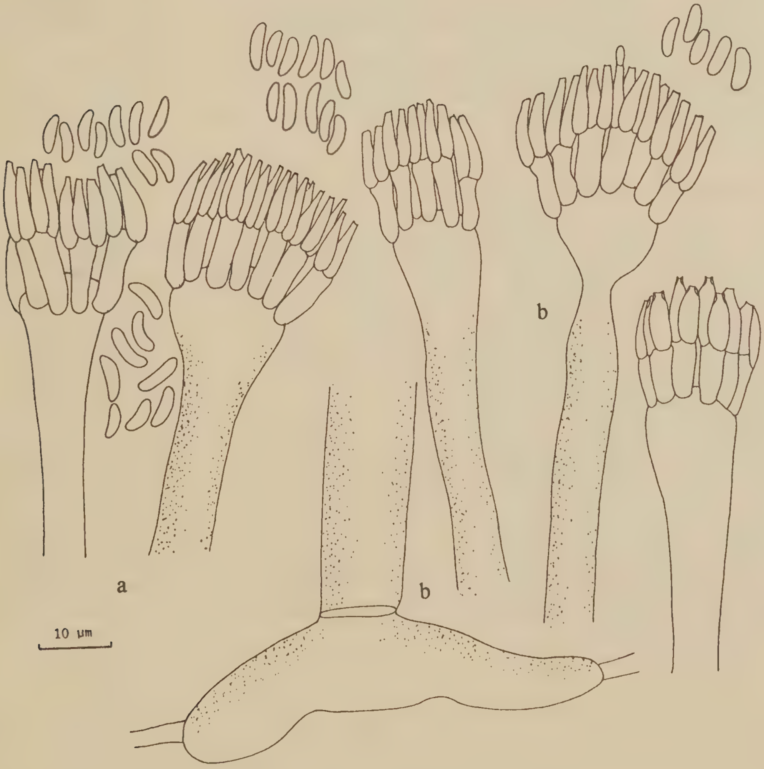

Fig. 2. *Goidanichiella barronii*, conidiophores and allantoid conidia. a. CBS 101.89, b. CBS 998.87.

No antibiotic properties were found against *Candida tropicalis*, *C. parapsilosis*, *C. albicans*, *C. glabrata*, *Cryptococcus neoformans*, *Trichophyton rubrum*, *T. interdigitale*, *T. mentagrophytes*, *Epidermophyton floccosum*, *Microsporum canis*, *M. gypseum*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus faecalis* and *Mycobacterium smegmatis*.

A polysaccharide was produced at 24°C in liquid synthetic medium with corn steep liquor (1.5%).

Material examined:

Barron's material of *Goidanichiella* sp. (No. 10008) consisting of two dried cultures and two slides; from soil, roadside under grass cover, near Muskoka, Ont., 1961.
CBS 471.71, isolated by A. v. Klopotek from compost, F.R.G.
CBS 998.87 = CMPG 160, isolated from peaty soil, Dublin Co., Ireland, 1979, by R. Steiman and F. Seigle-Murandi.
CBS 101.89 = CMPG 426, type isolate, isolated from peaty soil, St. Marcellin, Isère, France, 1979, by R. Steiman and F. Seigle-Murandi.
IMI 278477 = CBS 587.89, isolated from *Cucumis melo*, Alberta, by R. J. Howard.

Variability of the species

In isolate CBS 101.89 from the beginning some conidiophores were found to form more divergent metulae and globose conidia, 3.5 × 2.5 μm besides others with allantoid conidia. From both types of conidiophores identical subcultures were obtained. In CBS 998.87 allantoid conidia were found to be predominating from the beginning. In Barron's material only conidiophores with subglobose or broadly ellipsoid conidia were found. In CBS 471.71 and IMI 278477 originally the type with subglobose conidia was observed (Fig. 3a). After prolonged cultivation the isolates had degenerated and only more slender, irregularly branching conidiophores (Fig. 3b) with allantoid conidia were observed (also M.A.J. Williams, pers. comm.). The two cultures could, however be recuperated in good shape with predominantly subglobose conidia from lyophilization (after 18 years) and liquid nitrogen (after 6 years) respectively (Fig. 3c).

Goidanichiella sphaerospora Matsushima, Icones Microfungorum a Matsushima lectorum, Kobe: 77. 1975 might represent a second species of the genus. In spite of the Latin diagnosis and typification, the species was not validly published by Matsushima (1975),

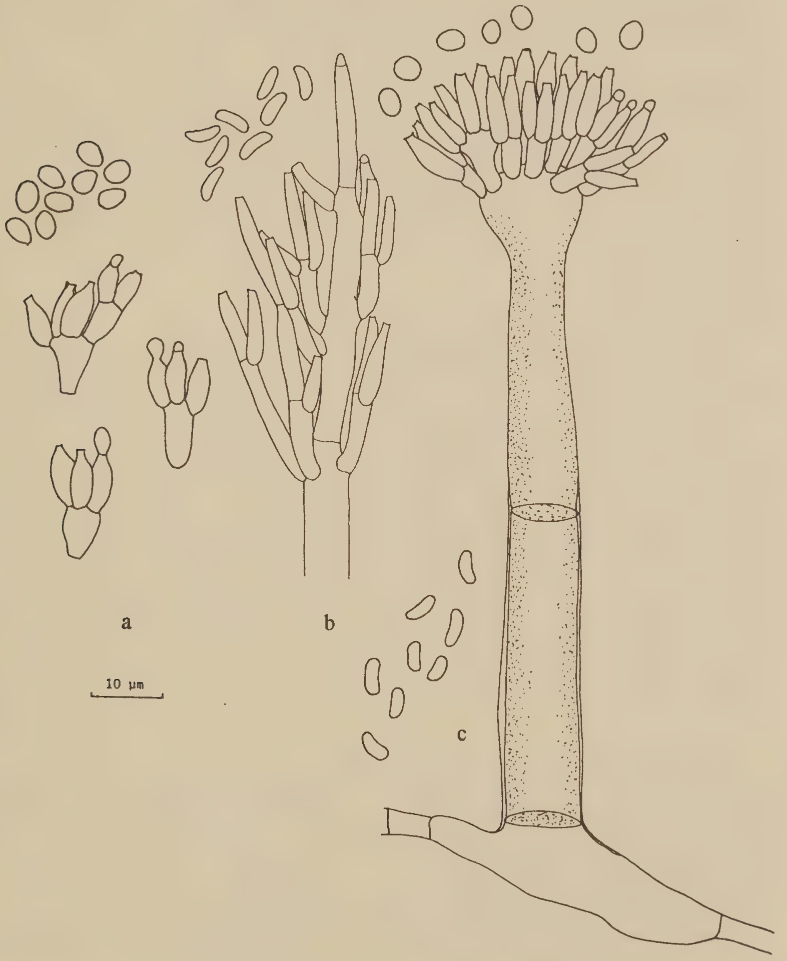

Fig. 3. *Goidanichiella barronii*, conidiophores and conidia. a. CBS 471.71 drawn 1971, b. after preservation on agar, drawn in 1989, c. after lyophilization, drawn in 1989.

as the genus was at that time not valid (Art. 43). The species seems to differ from the present fungus by broader conidiophores (up to 20 μm), vesicles (12—40 μm diam), metulae (4—6 μm wide) and phialides (3—4 μm wide). Conidia were observed only of the subglobose type. Unfortunately the species cannot be validated here because the type material, MFC 2613, has got lost (T. Matsushima, pers. comm.).

Acknowlegdements
We are greatly indebted to the correspondents mentioned in the text for information and material supplied. Drs G. L. Barron and M. A. J. Williams are thanked for reviewing the manuscript. Francis Snippe skilfully inked the drawings.

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TWO NEW SPECIES OF APHANOASCUS (ASCOMYCOTINA)

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SUMMARY

Aphanoascus australis *sp. nov.* and ***A. punsolae*** *sp. nov.* (Amauroascaceae) are described from soils in Chile and Spain respectively.

Members of *Aphanoascus* Zukal are widely distributed keratinophiles found in soils, dung and birds nests. They are readily isolated by the ToKaVa Hair Baiting Method (VANBREUSEGHEM, 1952). The genus has been recently revised by CANO & GUARRO (1990), who accepted 12 species. On the basis of ascospore morphology, two groups may be recognized, one with pitted or reticulate walls bearing an equatorial rim, and the other with pitted, reticulate or verrucose walls lacking the rim.

In the course of our ongoing studies on keratinophiles in Spanish and Chilean soils two interesting fungi were seen, one belonging to each of the two groups, and they did not share characteristics with any of the published species. They are herein described as new.

Aphanoascus australis Cano et Guarro *sp. nov.*

Etym: australis (L) - referring to the Southern Hemisphere, where the species was detected. FIG. 1

Anamorph: unknown

Hyphae vegetativae hyalinae, ramosae, 2 - 3 µm crassae.

Ascomata superficialia, sphaerica, non-ostiolata, levia, 300 - 550 µm diam., pallide brunnea; peridio 3 - 5 µm crasso, et 3 - 4 stratis cellularum complanatarum intricatarum composito, 4 - 5 µm constant. Asci octospori, globosi, evanescentes, 12 - 16 µm. Ascosporae irregulariter subglobosae vel oblatae, pallide brunneae, unicellulares, irregulariter reticulatae, 5.5 - 10 x 5 - 7.5 µm. Keratinophilica.

Holotypus: IMI 334819 (isotypus FMR 3045), isolatus ex solo, apud Puerto Varas, Chile, XI/1988.

Hyphae hyaline, branched, smooth, septate, 2 - 3 µm broad, thin-walled. Ascomata superficial, globose, non-ostiolate, light-brown, 300 - 550 µm diam, glabrous; ascoma wall of *textura intricata*, 3 - 5 µm thick, 3 - 4 layers deep, cells flattened, rather thick walled (0.5 - 1 µm), 4 - 5 µm broad. Asci numerous, globose, 12 - 16 µm diam, 8-spored, evanescent. Ascospores irregularly subglobose to oblate, unevenly reticulate, one-celled, pale to mid brown, 5.5 - 10 x 5 - 7.5 µm.

Keratinophilic.

Material examined: FMR 3045, from forest soil, Puerto Varas, Chile, XI/1988.

The description is based on material growing directly on hair, as all attempts to isolate the fungus failed. This species, along with ***A. keratinophilus*** Punsola & Cano and ***A. saturnoideus*** Cano & Guarro, are those described with the largest ascospores. ***A. australis*** is distinguishable by the shape and uneven ornamentation of its ascospores, apart from not growing on standard media. It belongs to the group of species lacking an equatorial rim. The most similar species is ***A. verrucosus*** Cano & Punsola, likewise with an irregular ascospore ornamentation but with smaller ascospores (4.5 - 6 x 3.5 - 4.5 µm) and with ***Chrysosporium tropicum*** Carmichael as its anamorph. The irregular shape of its ascospores is unique in the genus, whereas in all other species they are symmetrical. ***A. reticulisporus*** (Routien) Hubálek ascospores may occasionally be irregular in shape, but the ornamentation is regularly reticulate and the anamorph is a ***Chrysosporium*** with numerous intercalary conidia.

Aphanoascus punsolae Cano et Guarro *sp. nov.*

Etym: (L) punsolae = in honour of Dr L. Punsola. FIGS. 2,3

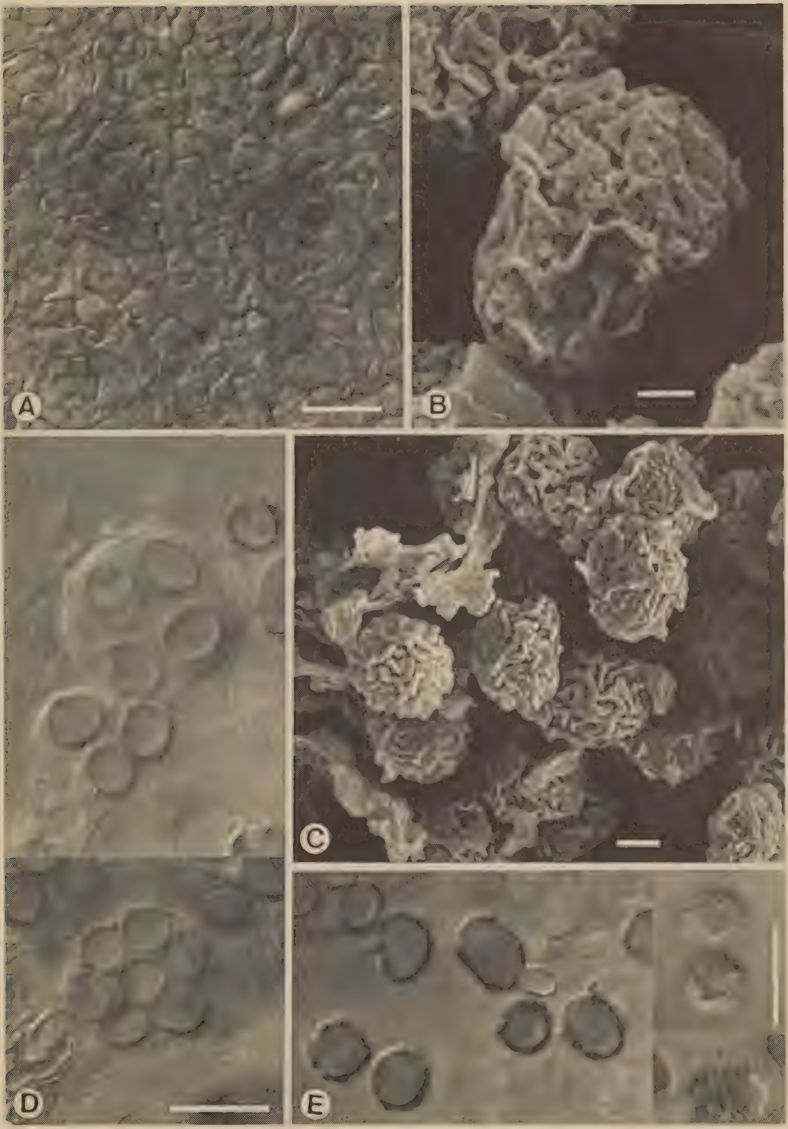
Anamorph ***Chrysosporium sp.***

Hyphae vegetativae hyalinae, ramosae, 2 - 2.5 µm crassae.

Ascomata superficialia, sphaerica, non-ostiolata, levia, 300 - 350 µm diam., pallide brunnea; peridio 3 - 5 µm crasso, et 3 - 4 stratis cellularum complanatarum angularum composito, 7 - 14 x 4 - 11 µm constant. Asci numerosi, octospori, subglobosi, evanescentes, 8 - 8.5 x 7 - 8 µm. Ascosporae subglobosae vel oblatae, pallide-brunneae vel brunneae, unicellulares, 4 - 4.5 x 2 - 2.5 µm. Conidia pyriformia, terminalia, lateralia et alternalia, sessilia vel in protrusionibus brevibus oriunda, solitaria, hyalina, crassitunicata, levia, 8.5 - 13 x 5.5 - 9 µm. Keratinophilica.

Holotypus: IMI 334818 (cultura sicca) (isotypus FMR 3067), isolatus ex solo, apud Alcudia de Veo, Castellón (Hispania), VI/1985.

Fig. 1. *Aphanoascus australis* (FMR 3045). A, peridium (N) (bar = 10 µm); B,C, ascospores (SEM) (bar = 1 µm); D, asci (N) (bar = 10 µm); E, ascospores (N) (bar = 10 µm).


A
B
C
D
E

Colonies on YpSs with a daily growth rate between 3 - 4 mm in the dark at 28°C; white, powdery, flat, margin defined and regular, small exudate drops are present in the submarginal area; reverse uncoloured. Hyphae hyaline, branched, septate, 2 - 2.5 µm broad, smooth, thin-walled. Ascomata superficial, globose, non-ostiolate, light-brown, 300 - 350 µm diam, glabrous; ascoma wall of *textura angularis* 3 - 5 µm thick, 3 - 4 layers deep; cells flattened, rather thick walled (0.5 - 1 µm), 7 - 14 x 4 - 11 µm. Asci numerous, globose to subglobose, 8 - 8.5 x 7 - 8 µm, 8-spored, evanescent. Ascospores subglobose to oblate, with a small equatorial rim, smooth to slightly rugose under SEM, poles raised conically and surrounded by a depression, one-celled, pale to mid brown, 4 - 4.5 x 2 - 2.5 µm. Conidia terminal and lateral, sessile or on short protrusions, hyaline, smooth, pyriform, thick-walled, 8.5 - 13 x 5.5 - 9 µm.

Colonies on PYE with a daily growth rate of 3 - 3.5 mm in the dark at 28°C or 37°C, white, powdery, flat, margin regular and defined; reverse uncoloured.

Keratinophilic.

Material examined: FMR 3067, Alcudia de Veo, Castellón, Aug 1985, arable soil; FMR 3284, Cervera del Maestre, Castellón, Aug 1985, arable soil; FMR 2819, Alcudia de Veo, Castellón, Aug 1985, garden soil; FMR 3285, Alcudia de Veo, Castellón, Aug 1985, forest soil; FMR 3286, Ahín, Castellón, Aug 1985, arable soil; FMR 3287, Torres-Torres, Valencia, Aug 1985, garden soil; FMR 3288, Cadiar, Granada, Aug 1985, arable soil; FMR 3289, Penyiscola, Castellón, Aug 1986, arable soil; FMR 3290, Lanjarón, Granada, Aug 1986, garden soil.

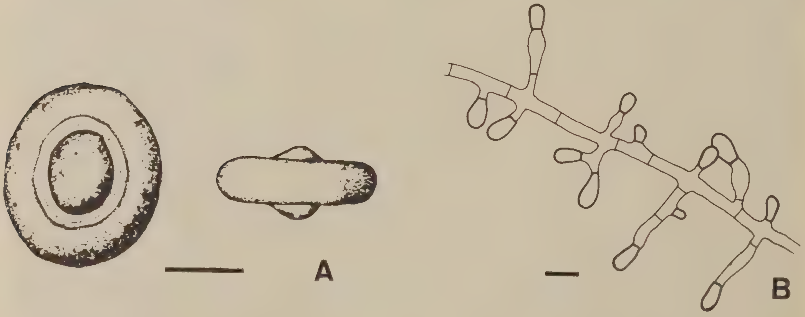
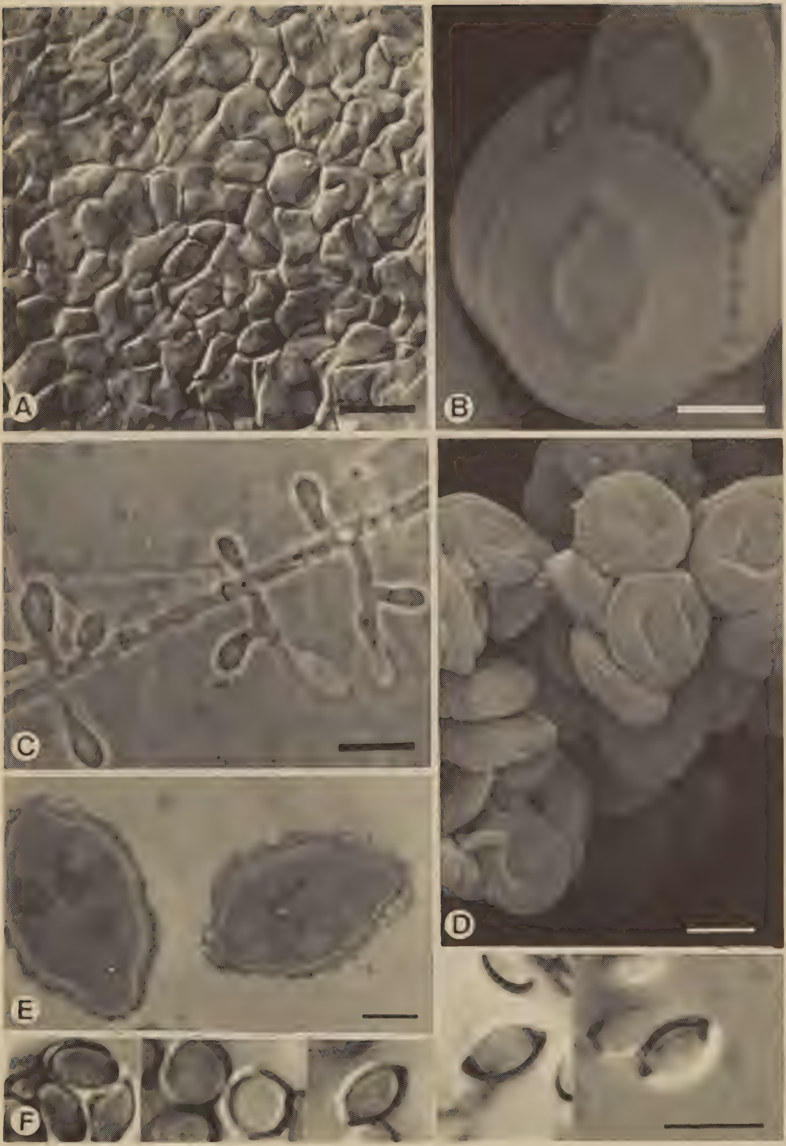


Fig. 2. *Aphanoascus punsolae* (FMR 3067). A, ascospores (bar = 2 µm); B, anamorph (bar = 10 µm).

Fig. 3.- *Aphanoascus punsolae* (FMR 3067). A, peridium (N) (bar = 10 µm); B, ascospores (SEM) (bar = 1 µm); C, anamorph (PC) (bar = 10 µm); D, ascospores (SEM) (bar = 2 µm); E, ascospores (TEM) (bar= 1 µm); F, ascospores (N) (bar = 10 µm).

N: Nomarski. SEM: Scanning Electron Microscope. TEM: Transmission Electron Microscope. PC: Phase Contrast.


A
B
C
D
E
F

Under the light microscope ascospores of this species closely resemble those of ***A. terreus*** (Randhawa & Sandhu) Apinis, but are larger (those of the latter are 5 - 6 x 2.5 - 3.5 µm). The equatorial rim on the ascospores (in polar view) is also much wider in ***A. terreus***. Both species further differ in their conidial anamorphs, that of ***A. terreus*** being ***Chrysosporium indicum*** (Randhawa & Sandhu) Garg and that of ***A. punsolae*** being a ***Chrysosporium*** with pyriform conidia. ***A. hispanicus*** Cano & Guarro differs in having a broad equatorial crest, while that of ***A. punsolae*** is narrow. Under SEM differences in ascospore morphology are even more obvious, those of a ***A. hispanicus*** bearing an entirely foveate surface except in the middle area. Those of ***A. punsolae*** are more or less rugose and bear conoid poles, while those of ***A. hispanicus*** are flat.

ACKNOWLEDGEMENTS

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VERONAEA CONSTRICTA, A NEW HYPHOMYCETE FROM EGYPTIAN SOILS

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ABSTRACT

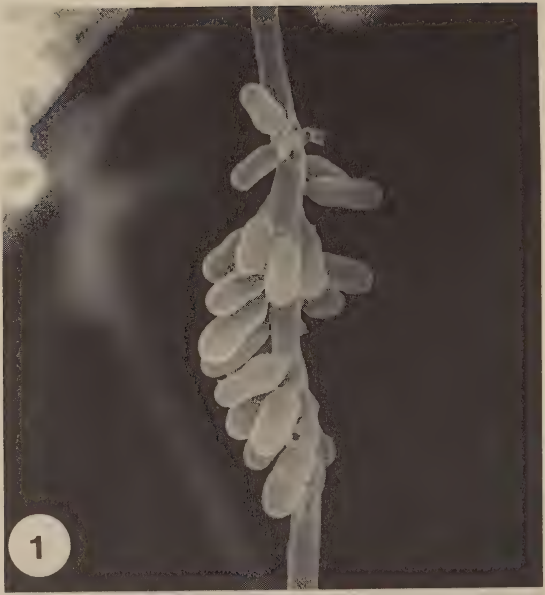
Veronaea constricta, a new species of dematiaceous Hyphomycetes, is described and illustrated from cultivated soil in Egypt. Conidia are distinctive, being smooth, two-celled, ellipsoid and conspicuously constricted at septa.

Key words: Veronaea, Hyphomycetes, Egypt, soil fungi.

During the course of investigations dealing with the ecology of fungi in various habitats in Egypt, an interesting species of Veronaea Ciferri & Mont. was recorded from a cultivated sand-loam soil in Ismailia. It has two-celled, smooth conidia. The prominent constriction of conidia is by far the most characteristic feature of this species. Such a character has not previously been reported for the genus (Ellis, 1971 & 1976; Geeson, 1973; Sharma & Munjal, 1979; Morgan-Jones, 1979 & 1982; Kamal & Kumar, 1980; Singh et al., 1981). It is formally described as a new species and briefly compared with related taxa.

Veronaea constricta Moustafa & A. Wahid sp. nov. (Fig.1-4)

Coloniae in agaro cum tuberibus Solani et radicibus Dauci cocto modice crescens, diametrum 3 cm 10 diebus temperatura 25^{o} celsii attingens, effusa, velutina, murina vel obscure murina (Rayner, 1970). Exsudatum superius nullum, reversum fusco-nigrum. Stroma, setae, hyphopodia nulla. Mycelium superficiale vel immersum, fusco-nigrum, parietibus laevibus, septatum, 2.0-2.5 µm diam. Conidiophora macronematica, mononematica, ramificata, recta vel flexuosa, olivaceO-fusca, laevia, 120-240x 1.5-2.5 µm magna. Cellulae conidiogenae polyblastae, septis instructae vel carentes, integratae, nunc terminalis nunc intercalares, discretae, sympodialiter ramosae, denticulatae, cylindricae, 30-70 x 2.5-3.5 µm diam. Conidia plerumque ellipsoida, late profunde constricta,



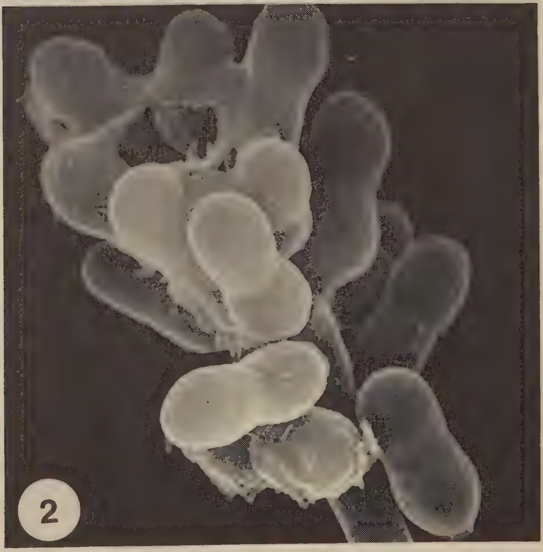
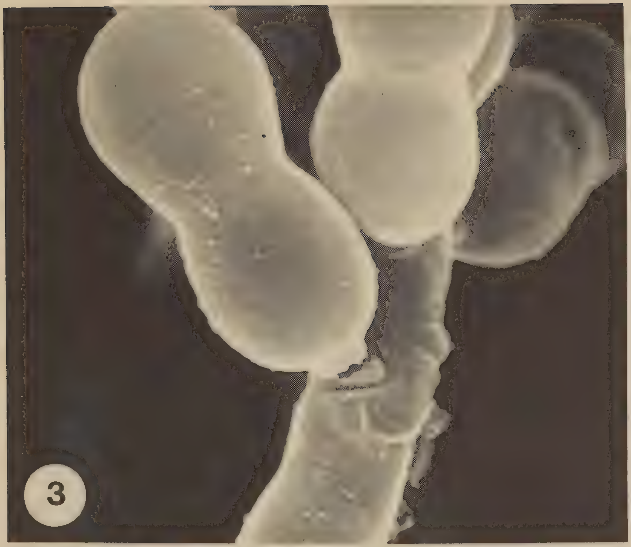


Fig. 1. Intercalary conidiogenous cell (SEM x 2000).
Fig. 2. Lateral conidiogenous cell (SEM x 4000)



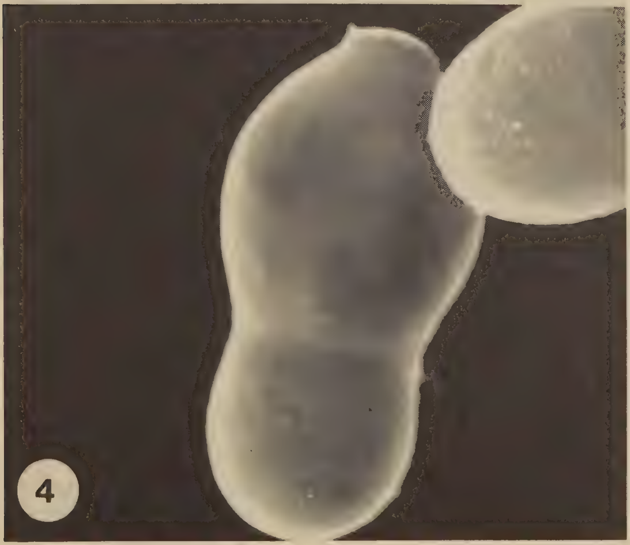


Fig. 3. Close up showing denticles and scars (x 8000).
Fig. 4. Conidia at high magnification showing smooth surface (x 15000).

intercalares, discretae, sympodialiter ramosae, denticulatae, cylindricae, 30-70 x 2.5-3.5 µm diam. conidia plerumque ellipsoida, late profunde constricta, subhyalina, laevia, septo cuique uno, 8-14 x 2.5-4.0 um magna, apice rotundata, basi cicatricem elevatam quidque praebentia.

Anno 1988 ad oppidum aegyptium Ismailia e terra culta, arenoso-argillosa lecta, ab A.F. Moustafa culta, holotypo sicco sub numero 327667 in Institute Mycologico Kewensi (IMI) deposito.

Colonies on potato carrot agar growing moderately, attaining a diameter of 3 cm in 10 days at 25 OC, effuse, velvety, Mouse-Grey to Dark Mouse Grey (Rayner, 1970). Exudate none, reverse Fuscus-Black. Stroma, setae and hyphopodia absent, Mycelium superficial to immersed, brownish-black, smooth-walled, septate, 2.0-2.5 µm wide. conidiophores macronematous, mononematous, branched, straight to flexuous, olivaceous-brown, smooth, 120-240 x 1.5-2.5 µm. Conidiogenous cells polyblastic, septate or non-septate, integrated, terminal and intercalary, discrete, sympodial, denticulate, cylindrical, 30-70 x 2.5-3.5 µm. Conidia mostly ellipsoid, subhyaline, usually 1-septate (occasionally 2-septate) subhyaline to pale brown, smooth, prominently constricted, 8-14 x 2.5-4.0 µm, round at the top, with truncate protuberant scar at the base.

Type IMI 327667, isolated from cultivated sandy loam soil in Ismailia, Egypt (1988), A.F. Moustafa.

Veronaea constricta by comparison differs markedly from the other septate species of the genus. First, V.caricis M.B. Ellis, V.smilacis Singh, Kamal & Abbasi, and V.gorakhpurensis Kamal & Kumar, are very distinct in producing relatively large conidia (usually more than 20 µm long) in contrast to other species which produce smaller conidia with fewer number of septa usually between 1-3. Except for V.carlinae M.B. Ellis where conidia are normally more than 12 µm long, all of the remaining septate species produce conidia less than 12 µm long. These species may be distinguished, however, by conidial shape, size, and texture. While conidia of V.coprophila (Subram. & Lodha) M.B. Ellis are cylindrical, they are almost clavate in V.tectonae Kamal & Kumar and very broad-ellipsoidal in V.verrucosa Geeson. The only species which can be compared with the new taxon are V.carlinae M.B. Ellis and V.botryosa ciferri & Mont. These taxa are characterized by cylindrical to narrow-ellipsoid conidia. However, the new taxon is easily distinguished by its deeply constricted, smooth conidia.

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NEW AND NOTEWORTHY POLYPORES FROM PARANÁ AND SÃO PAULO STATES, BRAZIL

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ABSTRACT

68 species of Polyporaceae (Aphyllophorales, Basidiomycetes) are listed from five localities in Southern Brazil. The species were gathered during a 3 year mycological survey. **Cerrena cystidiata** is described as new. The following rare species are recorded: **Ceriporiopsis latemarginata** (Rick) Rajchenb., **Coltricia duporti** (Pat.) Ryv., **Henningsia brasiliensis** (Speg.) Speg., **Phellinus apiahynus** (Speg.) Rajchenb. & Wright, **Ph. bambusarum** (Rick) Larsen, **Polyporus puttemansii** Henn., **Rigidoporus umbonatipes** Rajchenb. and **Spongipellis** aff. **caseosus** (Pat.) Ryv. **Antrodiella angulatopora** Ryv. is considered a synonym of **Ceriporiopsis latemarginata**, and **Phellinus garuhapensis** Wright & Blum. a synonym of **Ph. bambusarum**.

During a survey by one of us (AARM) of the macrofungi present in several protected areas in Paraná and São Paulo States, Brazil (de Meijer [1a,b]), some rare polypores were collected. Below is a list of the recorded species, with notes on the less known ones. Brazil lacks studies on

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[1a] MEIJER, A.R.R. de, 1988. Reconhecimento preliminar da Macrofungi flora da Area de Proteção Ambiental (APA) do município de Itu, Estado de São Paulo, Brazil. Curitiba, 35 pp. (ined.).

[1b] MEIJER, A.A.R. de, 1988. Reconhecimento preliminar da Macrofungi flora do Parque Marumbí (Paraná, Brazil). Curitiba, 77 pp. (ined.).

regional mycological floras and a good deal of work remains to be done in many phytogeographical areas in this country.

MATERIALS AND METHODS

Collections were made by the junior author from June 1979 through June 1980 and from January 1987 through October 1989 in numerous field trips made in the following areas (vegetations are name in accordance with Veloso & Góes-Filho, 1982):

A- São Paulo State, Municipality of Itu, Área de Proteção Ambiental (APA), "Bairro Taquaral"; alt. 610 to 710 m, between 23°22' and 23°25' S and between 47°15' and 47°19' W; in gallery forest in area of savana (campo 'cerrado').

B- Paraná State, Reserva Biológica Cambuí, Municipalities of Curitiba and São José dos Pinhais; alt. 870 m, 25°30'S and 49°11' W; in gallery forest in valley of the Iguazú river. This forest is flooded regularly by the annual cycle of the Iguazú.

C- Paraná State, Parque Estadual Marumbí; altitude varies from 20 m to 1922 m at the Paraná peak; between 25°06' and 25°36' S and between 49°01' and 49°13' W; in dense ombrophilous forest (pluvial forest of the Atlantic coast).

D- Paraná State, Municipality of Paranaguá, Estação Ecológica da Ilha do Mel; alt. 0 to 148 m, between 25°30' and 25°33' S and between 48°18' and 48°22' W; in 'restinga' forest, mangrove forest and dense ombrophilous forest.

E- Paraná State, Municipality of General Carneiro, Fazenda São Pedro; alt. 800 to 950 m, 26°22' S and 51°22' W; in mixed ombrophilous forest (forest with Araucaria angustifolia).

From the above mentioned areas, A, B and E belong to the Paranense phytogeographical province and, B and C, to the Atlantic phytogeographical province (Cabrera & Willink, 1973).

Some few collections made in places other than those mentioned above are specified in the text. These are all from the Paranense phytogeographical province, except a single collection from Florianópolis (Atlantic phytogeographical province). If not otherwise stated, the collections are from native forests.

Species are cited alphabetically according to genus, followed by the collecting place abbreviated with a letter (see above) and its collecting number. All specimens are kept at the junior author's private herbarium, but many of them have been split and are also kept at BAFC. Color notations were made according with Munsell (1954). Giemsa dying of nuclei in spores and mycelium followed Boidin's methodology (1958).

When possible, i.e. 5 or more specimens of a taxon were available for study, we have followed the suggestion of Parmasto & Parmasto (1987: 111) and calculated the 90% expected tolerance limits of the mean spore size at 90% probability level. Other factors determined include: $\bar{\bar{x}}$, the mean of means where more than one specimen is available; s, the standard deviation of a sample or the standard deviation of the mean values ($\bar{x}$) where more than one specimen were available; Q, the mean of the quotations of L/W in a n= 30 spores' sample of a specimen; $\bar{Q}$, the mean of Q values where more than one specimen is available. All the values are given to one decimal. The number of specimens studied for statistical analysis is indicated with N.

RESULTS

Amauroderma camerarium (Berk.) Furtado, C-961

Amauroderma schomburgkii (Mont. & Berk.) Torr., A-718, C-1096, E-1284 and E-1308

Amauroderma sprucei (Pat.) Torr., B-1039, Meijer 1248 (Paraná, Telêmaco Borba, Ind. Klabin, in Eucalyptus plantation)

Antrodia malicola (Berk. & Curt.) Donk, A-807

Bjerkandera adusta (Willd.:Fr.) Karst., B-64III and B-755

Ceriporia xylostromatoides (Berk.) Ryv., D-1210

This specimen is mostly resupinate but it also presents reflexed margins that form very narrow and small pilei, similar to those mentioned from the French Antilles by David & Rajchenberg (1985: 290). The microscopic examination revealed the presence of thin walled, claviform hymenial cystidia. These are similar in shape and in the cotton-blue reaction to those mentioned by the cited authors for two Gabonaise collections of the species (op. cit., pg. 291).

Ceriporiopsis latemarginata (Rick) Rajchenb., C-1023 and Meijer 1149 (Paraná, Piraquara, Fazenda Experimental UFPR, in Pinus plantation).

= Antrodiella angulatopora Ryv.

The species was described upon a single, rather good collection gathered by Rick in southern Brazil (Rio Grande do Sul State, São Salvador). The new findings confirm the presence of this species and allow us to enlarge its concept.

Fruit bodies are effused reflexed, fusing or not laterally. Pilei are narrow, thin and glabrous, with some very narrow dark concentric lines, white when fresh; upon drying they become straw coloured, rigid cartilagineous and curled. Pores are typically irregular, varying from angular to elongated daedaloid and to splitted-irpicoid.

The hyphal system is characterised by the presence of thick-walled generative hyphae. These may lack clamps along long portions of hyphae, for which reason they may be confused with skeletals. After the dissection of all the available materials we have confirmed the presence of clamps in all the hyphae. Ryvarden (1987: 527) stated, in reference to Antrodiella angulatopora (herein considered a synonym of this species) that "in the context there are very thick-walled hyphae 4-12 µm wide with a very few scattered clamps in addition to long segments of hyphae of the same width and without clamps, the latter type of hyphae are interpreted as skeletal hyphae". A similar statement was made by Rajchenberg (1987a: 554) in reference to C. latemarginata: "with thickened hyphae in the context...the latter with few clamps and may be confused with skeletal hyphae".

The similar hyphal types, fruitbodies' construction and macromorphological as well as microscopical features of C. latemarginata and A. angulatopora points toward a synonymy of both taxa. This fact was confirmed after the study of their respective holotype (at PACA) and isotype (at NY).

We are still dubious about the natural generic disposition of this species. Ceriporiopsis Dom. includes resupinate, monomitic species where some species present thick-walled hyphae and where fruit bodies may be tough and even resinous hard, e.g. C. gilvescens (Bres.) Dom. and C. rivulosa

(Berk. & Curt.) Gilbn. & Ryv. Antrodiella Ryv. & Johans. includes dimitic species with resupinate to pileate fruit bodies which are tough, cartilagineous and -sometimes- translucent when fresh; spores are typically small, under 4 µm long, ellipsoid to globose. But many of its features intergrade with species of the genus Flaviporus Murr. as defined by Ginns (1980), for which reason a more definite decision is here postponed until a more accurate study of species of all the three genera can be made.

Cerrena cystidiata Rajchenberg & de Meijer sp. nov.

Ad Cerrena unicolor (Bull.:Fr.) Murr. differt poris et dissepimenti minoribus, pilei dimidiatei castanei, systema hypharum dimiticum et gloeocystidia praesenti. Holotypus in herb. BAFC 31626, paratypus BAFC 31627.

Fruit bodies annual, lignicolous, flabellate to dimidiate, imbricate or laterally confluent, 2-6 cm radius x 2-9 cm wide x 3 mm thick. Pilei applanate, not thicker than 3 mm at the base, thinning towards the margin. Abhymenial surface tomentose, intensively zonate, with or without glabrous zones, dark brownish (5YR3/3 to 4/6) to dark beige (7.5YR6/6 -5/6). Hymenial surface poroid-daedaloid at the margin, pores 2-3 per mm, soon becoming totally splitted and irpicoid, with sword-like dissepiments 3-3.5 per mm, with more or less irregular configuration. Hymenial surface brown to dark brown (7.5YR5/4 to 5/6). Context cream coloured, separated from the dark tomentum by a black line; up to 1-1.5 mm thick. Dissepiments up to 1.5 mm long.

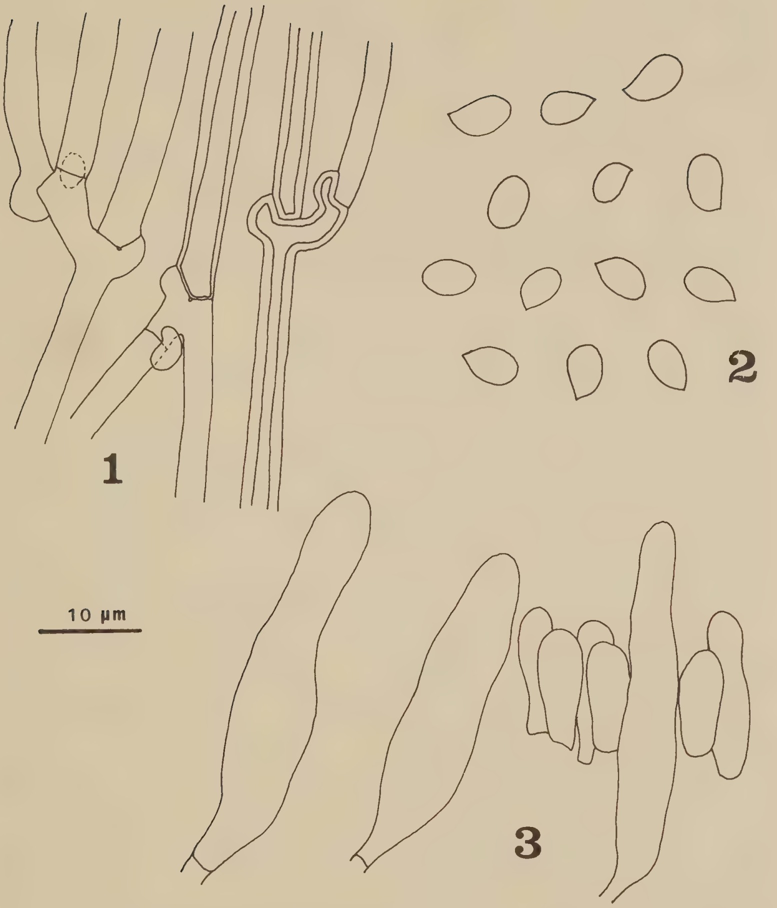
Hyphal system dimitic. Generative hyphae with clamp connections, 3-4.5 µm diam., with thin (but distinct) walls in the trama and the context and with thickened walled ones in the context and the tomentum (Fig. 1). Skeletal hyphae 2-4.5 µm diam., rarely branched to unbranched, with hyaline to yellowish, thickened walls, present throughout the fruit body.

Basidia 18-20 x 5-6 µm. Spores ellipsoid to broadly ellipsoid, hyaline, 5.0-5.8 x 3.2-3.8 µm ($\bar{x} \pm s = 5.4 \pm 0.4$ x 3.5 ± 0.3 µm), Q= 1.51, thinnwalled, IKI -, binucleate (Fig. 2). Gloeocystidia common to rare, enclosed in the dissepiments, protruding through the hymenium up to 10 µm, claviform, 30-40 x 5-7 µm, giving a negative reaction with sulphobenzaldehyde, sometimes difficult to find (Fig. 3).

Holotype: Brazil, Paraná State, São José dos Pinhais, ADEA-reserve "Reserva Biológica Cambuí", on dead but still standing tree of Sebastiana commersoniana, leg. A.A.R. de Meijer nº 1169, 22.V.1988 (BAFC 31626). Paratype: ibid., leg. ipse nº 851, 21.VI.1987 (BAFC 31627).

Remarks: the species is distinct on account of its more crowded dissepiments, the dimidiate-flabellate (never effused-reflexed) pilei, the abhymenial brownish colouration, the hyphal system and the presence of gloeocystidia (leptocystidia). Cerrena unicolor (Bull.:Fr.) Murr. exhibits pale brownish to grayish abhymenial surfaces in its fruit bodies, which may also be effused-reflexed; its pores are less splitted and spines are less crowded; its hyphal system is trimitic and it also lacks gloeocystidia.

The species seems to be rare, since the junior author



Figs. 1-3, **Cerrena cystidiata** Rajchenb. & de Meijer (from holotype BAFC 31626). 1, thin and thick walled generative hyphae; 2, spores (from spore print); 3, gloeocystidia.

has found it only twice in the type locality. Nevertheless, on both occasions (in two different neighbouring trees) pilei appeared in thousands so it seems that the species is difficult to overlook.

Coltricia duporti (Pat.) Ryv., Meijer 1321 (Paraná, S. Mateus do Sul, Fazenda Durgo, in forest, at bases of living Syagrus romanzoffiana, Palmae).

Our specimen was confronted with the holotype at FH (n° 3149, Xanthocrous duporti, Camayene, Guinée Française,

M. Duport 1910, sur tronc de Palmier), proving to be the same taxon. This is the second collection other than the type and expands its distribution to the neotropics. The species is remarkable because of its association with palms. Good descriptions may be found in Patouillard (1912: 34) and in Ryvarden (1983: 15).

Coltriciella oblectabilis (Lloyd) Kotl., Pouz. & Ryv., D-1233
Coriolopsis rigida (Berk. & Mont.) Murr., A-869, C-1017, E-1381 and Meijer 1226 (Paraná, Ponta Grossa, Parque Estadual de Vila Velha).
Coriolopsis polyzona (Pers.) Ryv., C-883
Earliella scabrosa (Pers.) Gilbn. & Ryv., C-794
Echinoporia aculeifera (Berk. & Curt.) Ryv., B-838, C-822 and E-1309
Favolus brasiliensis (Fr.) Fr., B-423
Favolus tessellatus Mont., B-148b
Flaviporus brownei (Pers.) Donk, E-1289
Flaviporus hydrophilus (Berk. & Curt.) Ginns, C-967
Flaviporus liebmanni (Fr.) Ginns, C-795
Fomitella supina (Sw.:Fr.) Murr., C-886 and E-1261
Fomitopsis meliae (Underw.) Gilbn. & Ryv., C-1018
Fuscocerrena portoricensis (Fr.) Ryv., B-773
Ganoderma lucidum (W.Curt.:Fr.) Karst., Meijer 1194 (Paraná, Curitiba, Jardin das Americas, Centro Politécnico)
Ganoderma parvulum Murr., B-850
Ganoderma subfornicatum Murr., C-962 and D-1234
Ganoderma tornatum (Pers.) Bres. complex, B-23, Meijer 1317 (Paraná, S. Mateus do Sul, Fazenda Durgo), Meijer 1191 (Santa Catarina, Florianópolis, Lagoa do Perí)
Gloeophyllum striatum (Sw.) Murr., A-864
Gloeoporus dichrous (Fr.) Bres., A-937 (in Cryptomeria plantation), B-151, C-882 and Meijer 893 (Paraná, Iratí, IBDF-reserve, in Pinus plantation, comm. A.F. Moraes)
Grammothele subargentea (Speg.) Rajchenb., A-938
Henningsia brasiliensis (Speg.) Speg., C-963

This species was re-described by Ginns (1979: 306) based on herbarium materials. Our large specimen presents the principal features, which were also present in the holotype (at LPS): thin, flabellate fruit bodies, small globose spores with thickened walls, small pores, monomitic hyphal system with simple septated generative hyphae. Nevertheless, our material lacked gloeopleurous hyphae.

The hymenial configuration deserves a commentary. Möller (1897: 231), when defining the genus Henningsia, characterised it by its merulioid hymenial configuration at the margins, which become poroid towards the center of the fruit body, and the hymenial layer readily separating from the context. Our material exhibits 'merulioid' areas (in aspect) consisting in poroid nets "drawn" on the hymenial side of the pilei. These very shallow pores, delimited by thread--like dissepiments do appear as merulioid, but they are sterile and no hymenium was seen on them. In the basal parts of the fruit bodies the pores are better defined and the dissepiments become longer, and their margins remain sterile. Similar 'merulioid' configurations may be found in the growth areas of the fruit bodies of other polypores, as Rigidoporus sanguinolentus (Fr.) Donk and some Ceriporia Donk species.

We were unable to observe whether the hymenial layer readily separates from the context or not.

Heteroporus biennis (Fr.) Láz., Meijer 1368 (Paraná, Curitiba, Pontificia Univ. Católica, on soil)
Hexagonia hydnoides (Fr.:Sw.) M. Fidalgo, A-862
Hexagonia papyracea Berk., A-810
Inonotus jamaicensis Murr., E-1260
Inonotus splitgerberi (Mont.) Ryv., B-787

This species is unique among the Hymenochaetaceae for its fruit body becoming permanently red to dark red with 5% KOH solution, and not black as typically in other members of that family.

Irpex lacteus (Fr.:Fr.) Fr., A-861
Junghuhnia undigera (Berk.) Ryv., E-1378, Meijer 812 (Paraná Colombo, in Pinus plantation), Meijer 1250 (Paraná, Telêmaco Borba, Ind. Klabin, on dead branch in Pinus elliottii plantation)
Lenzites betulina (Fr.) Fr., E-1259
Megasporoporia setulosa (Henn.) Rajchenb., B-72 and B-739
Microporellus obovatus (Jungh.) Ryv., C-966 and E-1286
Navisporus sulcatus (Lloyd) Ryv., E-1379, Meijer 1322 (Paraná, S. Mateus do Sul, Fazenda Durgo)
Pachykytospora alabamae (Berk. & Curt.) Ryv., B-784, B-785 and D-1338
Perenniporia medulla-panis (Jacq.:Fr.)Donk, A-808 and E-1355
Phellinus apiahynus (Speg.) Rajchenb. & Wright, Meijer 1225 (Paraná, Ponta Grossa, Parque Estadual de Vila Velha)

This species belongs to the Phellinus robustus (Karst.) Bourd. & Galz. complex. It differs on account of its triquetrous, smaller fruit bodies with grayish-chestnut pore surface, narrowly and densely sulcate pileus, and smaller spores (5-6 x 4.5-5 µm).

Phellinus bambusarum (Rick) Larsen, E-1287 and E-1315, on dead bamboo stems.

These well developed specimens present the typical features of the species: a resupinate habit, scattered, lanceolate, small sized hymenial setae, hyaline globose thick-walled dextrinoid spores and a bamboo host (cfr. Rajchenberg 1987b: 562).

Phellinus garuhapensis Wright & Blumenfeld (1984: 420) is a synonym of Ph. bambusarum. The holotype (at BAFC) is a poorly developed specimen of Ph. bambusarum. The setae are difficult to find and many of the spores lack a dextrinoid reaction. Nevertheless, we have noted their presence where the tubes are formed better.

Phellinus gilvus (Schw.) Pat., B-362
Phellinus merrillii (Murr.) Ryv., B-77II
Phellinus pectinatus (Kl.) Quél., C-964
Phellinus punctatus (Fr.) Pil., C-885
Phellinus sancti-georgii (Pat.) Ryv., D-1235 (on standing dead trunk of Callophylum brasiliensis)
Phellinus tropicalis Larsen & Lomb., C-828
Phellinus umbrinellus (Bres.) Herrera & Bondartseva, B-766

Phylloporia chrysita (Berk.) Ryv., C-827
Polyporus arcularius Batsch:Fr., A-936
Polyporus arcularioides David & Rajchenb. vel aff., E-1380
Polyporus guianensis Mont., B-263b
Polyporus leprieurii (Mont.) Pat., C-796
Polyporus puttemansii Henn., Meijer 1197 (Paraná, Curitiba, Parque Barreirinha, in native forest)
Polyporus squamosus Huds.:Fr., C-910
Polyporus tricholoma Mont., C-965
Postia subcaesia (David) Jülich, B-775
Pseudofavolus cucullatus (Mont.) Pat., B-340
Pycnoporus sanguineus (Fr.) Murr., B-19
Rigidoporus lineatus (Pers.) Ryv., B-20

Rigidoporus umbonatipes Rajchenb. vel aff., C-884

The specimen was growing in an abandoned railroad tunnel growing in an almost complete darkness. The following differences in macro- and micromorphology are perhaps due to that special micro environment. For a description of typical specimens see Rajchenberg (1987a: 116).

Fruit bodies are round and very small, 1-1.5 mm diam., fused together and forming a single pendent resupinate basidiocarp. Each small fruit body has a central, thread-like umbo up to 3-(4) mm long which attaches it to the substrate as shown by Rajchenberg (op. cit., fig. 8) but the stalks are thinner and longer. Microscopical features are alike, with exception of the presence of tramal, apically incrusted cystidia that protrude from the hymenium up to 40 µm (Fig. 4). Most of the fruit body is sterile and, this fact, together with the special environment where it was found, prevents us to make any different taxonomical decision.

A similar species seems to be Rigidoporus patelarius, described by Corner (1987: 179) from Borneo. It presents a similar fruit body macromorphology and incrusted tramal cystidia. But, according to the original description, spores are larger, viz. 5-6.5 x 4.5-6 µm and mammiform hymenial cystidia are absent.

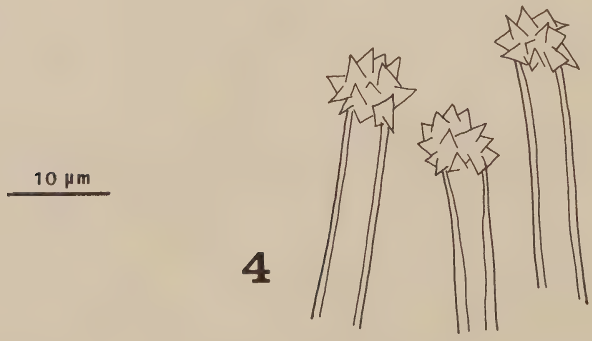


Fig. 4, **Rigidoporus umbonatipes** Rajchenb. vel aff. (coll. Meijer 884), incrusted cystidia.

Schizopora flavipora (Cke.) Ryv., B-757
Schizopora paradoxa (Schrad.:Fr.) Donk, B-747 and B-765

Spongipellis aff. **caseosus** (Pat.) Ryv., C-911, C-735b and Meijer 1166 (Paraná, Quatro Barras, in *Eucalyptus* plantation, growing on decayed stub of *Eucalyptus*). Rio Grande do Sul, Cambará do Sul, P.N. Aparados da Serra, Itaimbezinho, leg. R.M.B. da Silveira & R.T. Guerrero n° 78, 1.V.88 (=ICN 80447) and n° 154, 19.XI.88 (=ICN 80448)

Fruit bodies annual, lignicolous. Pilei flabellate, semicircular to more or less circular and pendent, convex to triquetrous in section, up to 3-4 cm wide, 1.5-6 cm radius and 1.1-1.5 cm thick. Rather soft-fleshy when fresh, slightly cartilagineous, whitish in the centre but becoming increasingly pinkish red towards the margin. Margin sharp and incurved. Upon drying waxy and cartilagineous in the lower context and the tubes, corky in the upper context. Abhymenial surface strigose with agglutinated hairs, pale pinkish to salmon pinkish when fresh, becoming very pale brown (10YR8/3-8/4) to yellowish tan (10YR8/6-8/8) upon drying. Context up to 1.3 cm thick; upon drying waxy-corky in the upper portion, towards the tubes presenting a cartilagineous reddish band. Tubes waxy, up to 3 mm long, reddish brown when dry (5YR4/6-5/6). Pores subgyrose, 1-2-3 per mm, compressed when dry, dentate to fimbriate. Pore surface pinkish red to salmon pinkish when fresh, upon drying fading or turning yellowish tan. Tubes up to 5 mm long. Taste absolutely mild.

Hyphal system monomitic. Generative hyphae with clamp connections, 4-5 µm diam.; in the upper context with hyaline walls 0.5 µm thick, agglutinated in groups but discernible. Groups of hyphae are arranged in different directions and leave spaces between them. In the lower context hyphae are wider, 4-8 µm diam., with yellowish walls up to 2 µm thick, more or less with a periclinal arrangement, totally agglutinated, indiscernible and inseparable, presenting a resinous matter among them. Generative hyphae in the trama 2.5-4 µm diam., with hyaline thickened walls and more or less agglutinated, presenting a resinous or oily substance between them; thinning towards the pore mouths.

Spores ellipsoid to broad ellipsoid, 4.6-6.0 x 3.3-4.3 µm ($\bar{x} \pm s$= 5.3 ± 0.3 x 3.8 ± 0.2 µm), $\bar{Q}$= 1.42 (N=5), with thickened walls, IKI -, abundant (Fig. 5). Cystidioles lageniform to mamiform, present or absent, 25-30 x 5-7 µm; some may be sclerified. Basidia claviform, tetraspored, 18-25 x 6-7 µm.

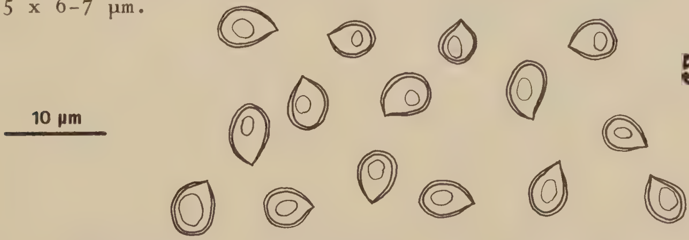


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Fig. 5, **Spongipellis** aff. **caseosus** (Pat.) Ryv. (coll. Meijer 1166), spores.

Cytological studies

Spores: uninucleate

Monosperms: two monosporous cultures obtained from coll. n° 1166 showed the hyphae to be simple septate and exhibited coenocytic articles. Some arrays of nuclei made from the terminal cell backwards are:

5-4-1-1-
7-2-3-1-
36-3-2-4-2-4-1-2-
43-3-2-1-2-

Polysperm: it was obtained from a spore print from coll. n° 1166. It consisted of mycelium with hyphae bearing a clamp at each septum, and is presumed to be dikaryotic. When this mycelium was submerged in liquid media, either in the top of it (viz., aerobic conditions) or in the bottom (viz., anaerobic conditions) and, once grown, transferred to a slide and covered with a collodion film (according to Boidin's methodology, 1958) this mycelium lost its clamps totally, giving rise to a simple septated mycelium with coenocytic articles. The latter is shown in the following array of nuclei made from the terminal cell backwards:

P↑[2]: 34-5-2-
12-4-7-
102-1-2-1-1-2-
16-5-2-2-

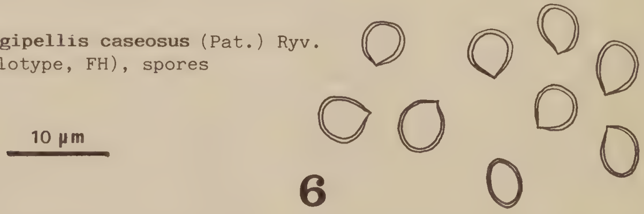
P↓[2]: 22-2-3-2-1-2-
8-2-2-2-
4-2-2-1-2-1-

Sexuality: heterothallic, but the type of polarity was not established.

Nuclear behavior: seemingly astatocoenocytic.

Remarks: *Spongipellis caseosus* (Pat.) Ryv., described from São Paulo State, Campinas (holotype studied, FH) is very similar. For a description see Ryvarden (1983: 11). It differs in lacking a waxy or cartilagineous fruit body and in being homogeneously corky. It does not present a dark red cartilagineous band above the tubes upon drying. Accordingly, hyphae are not glued into a resinous matter, are not so thick walled and are discernible and easily separated throughout the fruitbody. Spores are smaller and mostly subglobose, 4.7-5.1 x 3.6-4.2 µm ($\bar{x} \pm s = 4.9 \pm 0.2$ x 3.9 ± 0.3 µm) with a Q= 1.25 (Fig. 6). Nevertheless, ellipsoid spores are also present in the type material which are very similar in shape and size to the smaller ones present in our specimens.

Fig. 6, **Spongipellis caseosus** (Pat.) Ryv. (from the holotype, FH), spores



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[2] P↑ : polyspermic mycelium grown at the top of the liquid media in the test tube.
P↓ : polyspermic mycelium grown at the bottom of the liquid media in the test tube.

Our collections come also quite close to another taxon, viz. *Polyporus pulcherrimus* Rodw., described from Australia and Tasmania by Cunningham (1965: 121) under *Tyromyces* Karst. The study of several collections from the PDD, MEL and BPI[3] herbaria have convinced us that these specimens are conspecific with the Brazilian ones, the morphology being highly similar both in fresh and in dried conditions. The spores are similar in shape and size (Fig. 7), 5.5-6.2 x 3.8-4.3 µm ($\bar{x} \pm s = 5.8 \pm 0.3 \times 4.0 \pm 0.3$ µm), $\bar{Q} = 1.45$ (with N= 5), and also the hyphae are agglutinated in the same fashion. However, it is stricking the atypical distribution of all the specimens when they are put together. We prefer, then, to maintain Patouillard's name for our Brazilian collections until more specimens can be made in the topotype of *Leptoporus caseosus* and until we can get a better understanding of its morphological variation.

The cytological studies support the disposition of our specimens in *Spongipellis* Pat., as other species in the genus have also been shown to be astatocoenocytic (David, 1969). Spores' features and the hyphal system also support this disposition. Anyway, its anatomical features remain doubtful since it presents a cartilagineous context which reminds of many species in the genus *Flaviporus* Murr.

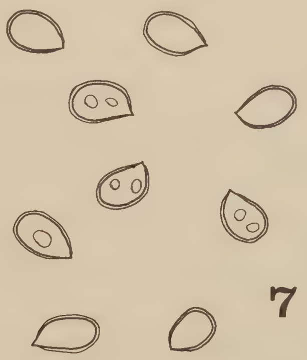

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Fig. 7, **Polyporus pulcherrimus** Rodw. (coll. BPI, Lloyd herb. n° 53403), spores

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[3] PDD 55188, Tasmania, Franklin Lower Gordon Wild Rivers Nat'l Park, Lyell Highway, Franklin River Br., on *Nothofagus cunninghamii*, leg. A. Mills, 17.V.87; PDD 55163, ibid., leg. P.K. Buchanan, 17.V.87; MEL 1048181, Australia, Victoria, Mt. Buffalo Plateau, at the camping ground on Lake Catani, growing on charred base of an old *Eucalyptus pauciflora*, 4500 ft. alt., leg. J.H. Willis, 21.II.63; MEL 1048179, ibid., in a creek 3.5 miles W of Cumberland Falls, on old fallen log of *Nothofagus* sp., leg. J.H. Willis, 26.I.48; BPI, Lloyd's Herb. cat. n° 53403, Tasmania, leg. & det. L. Rodway.

Trametes elegans (Spreng.:Fr.) Fr., A-717

Trametes versicolor (L.:Fr.) Pil., B-783, E-1262 (on dead branch of Araucaria angustifolia)

Trametes villosus (Fr.) Kreisel, B-14

Trichaptum biforme (Fr. in Kl.) Ryv., A-870

Trichaptum sector (Fr.) Kreisel, B-774, D-1339 (on dead mangrove, Laguncularia racemosa)

Tyromyces leucomallus (Berk. & Curt.) Murr., C-968

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MYCOTAXON

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TYPE STUDIES IN TYLOPILUS. IV.
TAXA DESCRIBED BY ROLF SINGER. 1.

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ABSTRACT

Studies of type specimens of five *Tylopilus* taxa described by Rolf Singer, *T. appalachiensis, T. cellulosus, T. minor, T. peralbidus* var. *rhodoconius*, and *T. tabacinus* var. *dubius*, are presented. Microscopic anatomical details are re-evaluated in light of modern terminology. Lectotypes are designated for *T. minor, T. peralbidus* var. *rhodoconius*, and *T. tabacinus* var. *dubius. Tylopilus cellulosus*, a west African species, has a number of characters intermediate between *Tylopilus* and *Porphyrellus*.

Key Words: Boletales, *Tylopilus*, lectotypes, type studies.

INTRODUCTION

Rolf Singer has described approximately sixteen taxa of *Tylopilus* many of which are from the western hemisphere. This contribution is the first in a series of papers re-evaluating the type specimens of *Tylopilus* taxa described by Singer.

Wolfe (1981, 1983, 1986) has redescribed the micromorphology of twenty-two type specimens of *Tylopilus* taxa. From these studies, it has been determined that among the micromorphological characters, the cystidia (e.g., pileus dermatocystidia, pleurocystidia, pseudocystidia, cheilocystidia, and stipe dermatocystidia) are taxonomically significant. Singer did not discriminate among the various cystidia in the original or subsequent descriptions of these taxa even though he provided definitions of them in later works (Singer, 1949, 1975, 1986). This contribution will present modern descriptions of the micromorphology of these taxa.

The type specimen of *Tylopilus tabacinus* (Peck) Singer var. *amarus* Singer could not be located among the collections at FH

(Cacavio, pers. comm.), FLAS (Kimbrough, pers. comm.), nor F (Dercole, pers. comm.) and has presumably been lost or misplaced.

MATERIALS AND METHODS

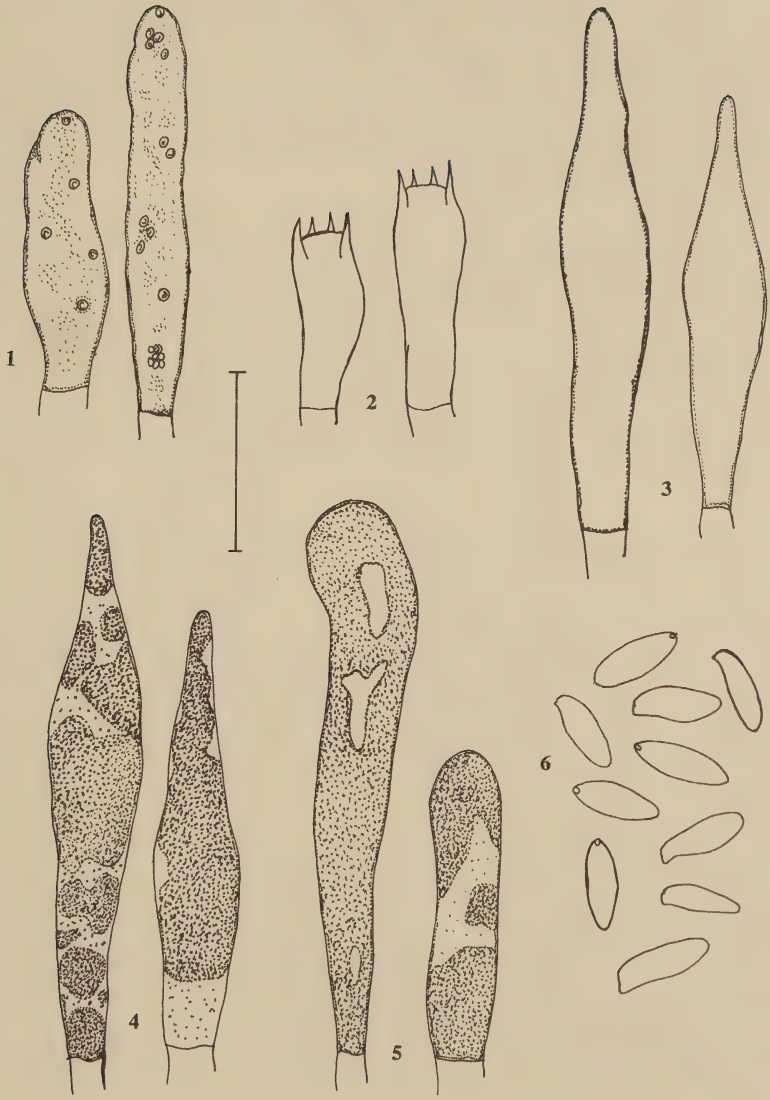
Methods used during these studies were described earlier (Wolfe, 1981, 1986; Wolfe and Halling, 1989). The basidiospore length/width ratio is presented as the E value and the mean E value is presented as E^M. Mean dimensions of microscopic characters are presented parenthetically by the symbol D^M. Color indications were determined either subjectively or by reference to Kornerup and Wanscher (1967). Herbarium designations are by Holmgren and Keuken (1974).

TAXONOMIC DESCRIPTIONS

Tylopilus appalachiensis Singer. Sydowia 2: 38. 1948.

Pileus cuticle an interwoven trichoderm; terminal cells (Fig. 1) 6.5-10.4 µm (D^M = 7.9 µm), cylindric with distal taper, hyaline to yellow and granular-oily in KOH, hyaline with gold spheres in Melzer's reagent; subcuticular hyphae hyaline in KOH and Melzer's reagent. Tube tramal hyphae 2.6-5.2 µm diam (D^M = 4.4 µm), bilateral-divergent (boletoid) , hyaline in KOH and Melzer's reagent. Oleiferous hyphae 2.6-6.5 µm diam (D^M = 5.3 µm), abundant, pale yellow in KOH, yellow-gold in Melzer's reagent. Clamp connections absent. Basidia (Fig. 2) 20.8-29.9 x 7.8-11.7 µm (D^M = 25.7 x 9 µm), clavate, 4-sterigmate, hyaline to opaque yellow in KOH, yellow in Melzer's reagent. Pleurocystidia (Fig. 3) 41.6-65 x 6.5-10.4 µm (D^M = 52 x 9.4 µm), fusoid-ventricose, narrowly fusoid-ventricose, hyaline to opaque in KOH and Melzer's reagent. Pseudocystidia (Fig. 4) 48.1-78 x 9.1-11.7 µm (D^M = 60 x 10 µm), fusoid-ventricose, yellow-gold in KOH, dark gold in Melzer's reagent, some with numerous golden spheres, some only with gold cytoplasm. Cheilocystidia (Fig. 5) 31.2-78 x 6.5-10.4 µm, (D^M = 50 x 8.8 µm), clavate and distally inflated, gold in KOH, dark gold in Melzer's reagent, contents irregularly dispersed. Stipe dermatocystidia not observed. Basidiospores (Fig. 6) 10.4-14.3 x 3.2-3.9 µm (D^M = 11.8 x 3.6 µm), E = 2.7-4.1 (E^M = 3.3), inequilateral in profile, narrowly elliptical in face view, yellow-green in KOH, pale yellow in Melzer's reagent, surface smooth, walls continuous without germ pore.

Type specimen: Holotype (FH) - "Coker 13286, North Carolina, Macon County, vicinity Highlands, roadside bank alongside Kalalanta Road, July 18, 1943". [!]



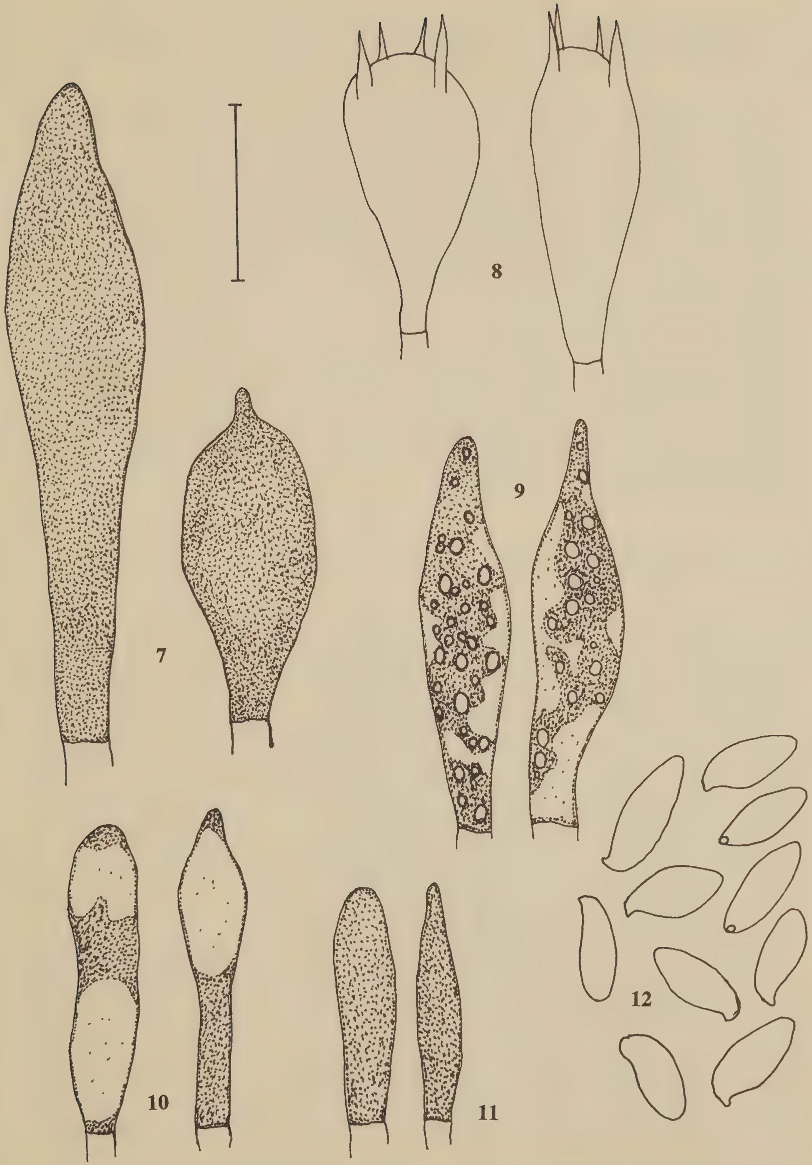
Figures 1-6 - ***Tylopilus appalachiensis*** Singer. Fig. 1 - terminal cells of the trichodermium. Fig. 2 - basidia. Fig. 3 - pleurocystidia. Fig. 4 - pseudocystidia. Fig. 5 - cheilocystidia. Fig. 6 - basidiospores. Reference line = 20 μm.

Discussion. Coker and Beers (1943) described *Boletus felleus* var. *minor* but without a Latin description thus making the name invalid at publication (Greuter, 1988). Singer (see above) described *T. appalachiensis* as a "nom. nov.," provided a latin description, and designated a type specimen (a Coker collection of *B. felleus* var. *minor*). *Tylopilus appalachiensis* was not a *nomen novum* but rather a new species altogether even though Singer chose a Coker specimen of the invalid *B. felleus* var. *minor*.

There is a complex of *Tylopilus* taxa that have a smooth to slightly reticulate stipe apex, brown pileus and stipe, a bitter taste, and pseudocystidia. *Tylopilus appalachiensis* is distinct from *Tylopilus felleus* (Fr.) Karsten in that it lacks a pronounced stipe reticulum, has darker pileus colors, and has a darker colored stipe base. In *T. appalachiensis*, two microscopic characters have potential taxonomic significance - the pileus cuticle and the pseudocystidia. Terminal cells of the trichodermium and some pseudocystidia have golden spheres in Melzer's reagent, unusual states of these characters in *Tylopilus* taxa.

Tylopilus cellulosus Singer. Am. Midl. Naturalist 37: 105. 1947.

Pileus cuticle a hymeniform layer of dermatocystidia; pileus dermatocystidia (Fig. 7) 32.5-74.1 x 13-22.1 μm (D^M = 52.9 x 18.1 μm), sordid yellow-tan in KOH and Melzer's reagent; surface and hypoderm littered with extracellular dextrinoid crystals in Melzer's reagent. Tube tramal hyphae 2.6-9.1 μm diam (D^M = 5.5 μm), hyaline in KOH and Melzer's reagent. Oleiferous hyphae 3.9-10.4 μm diam (D^M = 6.1 μm), granular-oily, ocher in KOH and Melzer's reagent. Clamp connections absent. Hymenium littered with dextrinoid crystals in Melzer's reagent. Basidia (Fig. 8) 29.9-44.2 x 7.8-14.3 μm (D^M = 38.7 x 10.9 μm), clavate, 4-sterigmate, sordid yellow-tan in KOH, dark ocher in Melzer's reagent; sterigma 5-6.5 μm long. Pleurocystidia absent. Pseudocystidia (Fig. 9) 37.7-53.3 x 9.8-10.4 μm (D^M = 45.5 x 10.2 μm), rare, fusoid-ventricose, sordid yellow-tan in KOH, sordid ocher in Melzer's reagent, cytoplasm granular-oily. Cheilocystidia (Fig. 10) 30-49.4 x 6.5-9.8 μm (D^M = 41.5 x 7.6 μm), spathulate-pedicellate, hyaline in KOH, yellow in Melzer's reagent. Stipe dermatocystidia (Fig. 11) 20.8-36.4 x 6.5-9.8 μm (D^M = 27 x 7.5 μm), versiform (ventricose, cylindric, subclavate), cream yellow to yellow in KOH, ocher in Melzer's reagent. Caulobasidia present. Basidiospores (Fig. 12) 11.7-14.3 x 4.5-6.5 μm (D^M = 13.1 x 5.3 μm), E = 2.2-2.9 (E^M = 2.5), inequilateral in profile, elliptical in face view, cream-yellow in KOH, yellow-cinnamon in Melzer's reagent, surface smooth, walls dark brown in Melzer's reagent and continuous without germ pore.



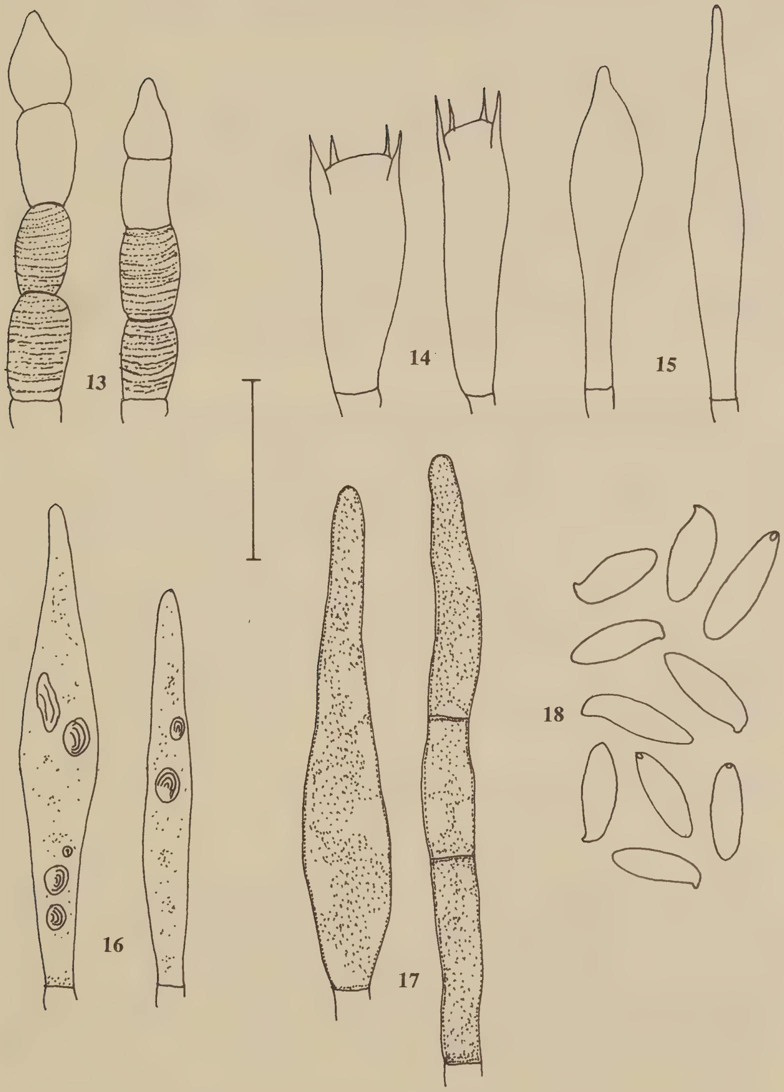
Figures 7-12 - ***Tylopilus cellulosus*** Singer. Fig. 7 - pileus dermatocystidia. Fig. 8 - basidia. Fig. 9 - pseudocystidia. Fig. 10 - cheilocystidia. Fig. 11 - stipe dermatocystidia. Fig. 12 - basidiospores. Reference line = 20 μm.

Type Specimen. Holotype (FH) - "Liberia: Nengbe; Apr. 9. 1939; G. W. Harley, no. 60; det R. Singer." [!]

Discussion. The pileus cuticle in this taxon, a hymeniform layer of pileus dermatocystidia, is not unique among *Tylopilus* species (Wolfe, 1986) but is noteworthy because of the pigmentation and size of the cystidia. Dextrinoid crystals are abundant in all tissues (pileus, stipe, hymenium), and their presence is unique among *Tylopilus* taxa. Morphology of the cheilocystidia is unusual among *Tylopilus* subg. *Tylopilus* taxa but is very reminiscent of taxa in *Tylopilus* subg. *Porphyrellus* (Gilbert) Smith & Thiers. Cheilocystidia are, however, smaller in *T. cellulosus* than in other taxa of *Tylopilus* subg. *Porphyrellus*. The relatively large basidiospores (D^M = 13.1 x 5.3 μm) with dark walls in Melzer's reagent are also reminiscent of taxa of *T.* subg. *Porphyrellus*. Although Singer (see above) reported this species as producing a pink spore deposit color, this taxon may belong in *Tylopilus* subg. *Porphyrellus*. If so, it will be the first occurrence of a true *Porphyrellus* taxon in Africa.

Tylopilus minor Singer. Mycologia 37: 799. 1945.

Pileus cuticle an interwoven trichodermium; terminal cells (Fig. 13) 15-39 x 6.5-13 μm (D^M = 25.9 x 8.8 μm), pyriform, cylindric, yellow in KOH, hyaline, gold, or bright gold in Melzer's reagent; subterminal hyphae with horizontally incrusting bands. Tube tramal hyphae 1.3-7.8 μm diam (D^M = 4.9 μm), bilateral-divergent (boletoid), hyaline in KOH and Melzer's reagent. Oleiferous hyphae 2.6-10.4 μm diam (D^M = 5.5 μm), gold in KOH and Melzer's reagent. Clamp connections absent. Basidia (Fig. 14) 25-37.7 x 9.1-11.7 μm (D^M = 31 x 10 μm), clavate, 4-sterigmate, opaque cream-yellow in KOH, yellow in Melzer's reagent. Pleurocystidia (Fig 15) 36.4-59.8 x 6.5-9.8 μm (D^M = 47.5 x 8.2 μm), fusoid-ventricose, opaque cream-yellow in KOH and Melzer's reagent. Pseudocystidia (Fig. 16) 37.7-52 x 6.5-10.4 μm (D^M = 48.6 x 8.1 μm), fusoid-ventricose, opaque cream-yellow in KOH, hyaline with dextrinoid spheres in Melzer's reagent. Cheilocystidia (Fig. 17) 45.5-111.5 x 5.9-13 μm (D^M = 75.3 x 8.2 μm), subcylindric, sublanceolate, very narrowly fusoid-ventricose, often secondarily septate, hyaline to yellow-gold in KOH, dark gold in Melzer's reagent. Stipe dermatocystidia not observed. Basidiospores (Fig. 18) 10.4-16.9 x 3.9-4.5 μm (D^M = 13.3 x 4 μm), E = 2.7-3.8 (E^M = 3.4), inequilateral in profile view, elliptical in face view, yellow in KOH, yellow and slowly subdextrinoid (slightly reddish orange) in Melzer's reagent, surface smooth, walls continuous without germ pore.



Figures 13-18 - ***Tylopilus minor*** Singer. Fig. 13 - terminal cells of the trichodermium. Fig. 14 - basidia. Fig. 15 - pleurocystidia. Fig. 16 - pseudocystidia. Fig. 17 - cheilocystidia. Fig. 18 - basidiospores. Reference line = 20 μm.

Type Specimen. Lectotype (FH, des. mihi) - "Kelly's Hammock, northwest of Gainesville, Alachua Co., Fla.; on the ground in hammock under oak, *Carpinus*, *Magnolia* etc. (no conifers); Coll. R. Singer; Det. R. Singer; July 25, 1943." [!]

A type specimen was not designated in the original description (Singer, 1945) but both "type" (F2717) and "co-type" (F2979) specimens were cited in a subsequent description (Singer, 1947). In effect, Singer designated F2717 as the lectotype. Unfortunately, that specimen is no longer among the collections of *Tylopilus minor* at the Farlow Herbarium (FH) and is presumed lost (Cacavio, pers. comm.). Specimen F2979 was selected as the lectotype from among several specimens available from FH (F2213, F2979, and F3425) because (1) it was collected from the type locality ("Kelley's Hammock prope Gainesville, Fla.") by Singer, and (2) it was later cited by Singer as the "co-type."

Discussion. Singer (1947) indicated that the [hymenial] cystidia had yellowish incrustations, a character state not observed in this study in either KOH or Melzer's reagent. Pseudocystidia and cheilocystidia are taxonomically significant characters in this taxon. Pseudocystidia have dextrinoid spheres, an uncommon character state among *Tylopilus* taxa. These spheres differ from those gold spheres in the terminal cells of the pileus cuticle in *T. appalachiensis* as presented above. The cheilocystidia are long and narrow (D^M = 75.3 x 8.2 μm). Of the type specimens studied so far in this series, most do not have cheilocystidia, but when they are present, their mean lengths have been much shorter. It appears that cheilocystidia will be an important diagnostic character for *Tylopilus* taxa.

Tylopilus peralbidus (Snell & Beardslee) Murrill var. ***rhodoconius*** Singer. Mycologia 37: 799. 1945.

Pileus cuticle a loose palisade trichodermium; terminal cells (Fig. 19) 31.2-65 x 3.9-7.8 μm (D^M = 47.5 x 5.1 μm), cylindric, equal, hyaline or gold in KOH, dark gold to olive-gold and granular-oily in Melzer's reagent. Tube tramal hyphae 5.2-9.1 μm diam (D^M = 7.4 μm), bilateral-divergent (boletoid), hyaline in KOH and Melzer's reagent. Oleiferous hyphae 2.6-6.5 μm diam (D^M = 3.9 μm), yellow-gold in KOH, dark ocher in Melzer's reagent. Clamp connections absent. Basidia (Fig. 20) 20.8-27.3 x 6.5-7.8 μm (D^M = 24.6 x 7 μm), clavate, 4-sterigmate, opaque cream in KOH, yellow in Melzer's reagent. Pleurocystidia (Fig.21) 42.9-65 x 5.8-8.5 μm (D^M = 54 x 7.5 μm), fusoid-ventricose, apex long and attenuated, hyaline in KOH and Melzer's reagent. Pseudocystidia (Fig. 22) 40.3-65 x 7.2-10.4 μm (D^M = 54.2 x 9 μm), gold in KOH, cytoplasm subdextrinoid and reticulate in Melzer's reagent. Cheilocystidia (Fig. 23) 26-32.5 x 5.2-6.5 μm (D^M = 28.6 x 5.9 μm), fusoid-ventricose to narrowly fusoid-ventricose, hyaline in KOH and Melzer's reagent. Stipe dermatocystidia (Fig. 24) 28.6-58.5 x 6.5-10.4 μm (D^M = 40.3 x 8.1 μm), versiform (clavate and fusoid-ventricose), hyaline to dark gold in KOH, yellow to dextrinoid in Melzer's reagent; caulobasidia present in caulohymenium. Basidiospores (Fig. 25) 8.4-11.7 x 2.6-3.3 μm (D^M = 9.8 x 2.7 μm), E = 2.9-4 (E^M = 3.6), subinequilateral in profile view, narrowly elliptic in face view, creamy yellow-green in KOH, opaque in Melzer's reagent, surface smooth, walls continuous without germ pore.

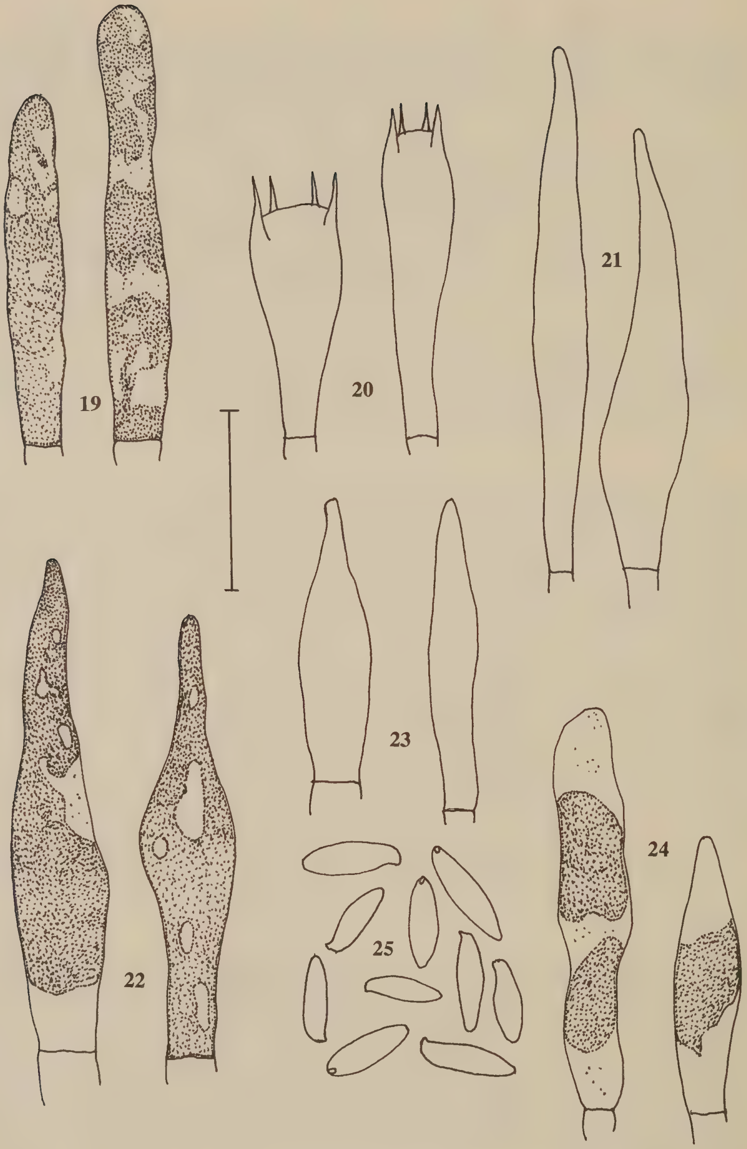
Type Specimen: Lectotype (des. mihi) (FH) - "Fungi Floridani; No. F2708a; on lawn under oak; Gainesville, Alachua Co., Fla.; Coll. R. Singer, Det. R. Singer; July 17, 1943; Type." [!]

Singer did not designate a holotype specimen in the protologue (Singer, 1945) nor did he designate a lectotype in a later description (Singer, 1947). Examination of collections at the Farlow Herbarium (FH) revealed a specimen with the word, "type," on the herbarium label. It appears that this specimen was used by Singer, and it is hereby designated as the lectotype.

Discussion. Wolfe (1986) studied the type of *Tylopilus peralbidus* (Snell & Beardslee) Murrill. Comparisons of results of studies of the type variety and *Tylopilus peralbidus* var. *rhodoconius* produced some interesting similarities and differences between them. Pleurocystidia are longer and attenuated in var. *rhodoconius*. Pseudocystidia are longer and broader in var. *peralbidus*. The reticulate appearance of the cytoplasm of the pseudocystidia were strikingly similar in both taxa. Surprisingly, cheilocystidia were absent in var. *peralbidus* but present in var. *rhodoconius*. Finally, basidiospore dimensions were very nearly identical.

Cheilocystidia are morphologically different from pleurocystidia (Singer, 1986). In *T. peralbidus* var. *rhodoconius* the cystidia on the tube walls and tube edges have the same shape, but their sizes are substantially different: pleurocystidia D^M = 54 x 7.5 μm; cheilocystidia D^M = 28.6 x 5.9 μm. In addition, the apices of these cystidia also differed morphologically. The apex of the pleurocystidia were mostly long and attenuated while the apices of the cheilocystidia were mostly short.

Basidiospore morphology is quite distinct in this specimen when compared with other taxa of *Tylopilus* (see above), very narrowly elliptical (E = 3.6). Three taxa studied here, *T. appalachiensis*, *T.*



Figures 19-25 - ***Tylopilus peralbidus*** var. ***rhodoconius*** Singer. Fig. 19 - terminal cells of the trichodermium. Fig. 20 - basidia. Fig. 21 - pleurocystidia. Fig. 22 - pseudocystidia. Fig. 23 - cheilocystidia. Fig. 24 - stipe dermatocystidia. Fig. 25 - basidiospores. Reference line = 20 μm.

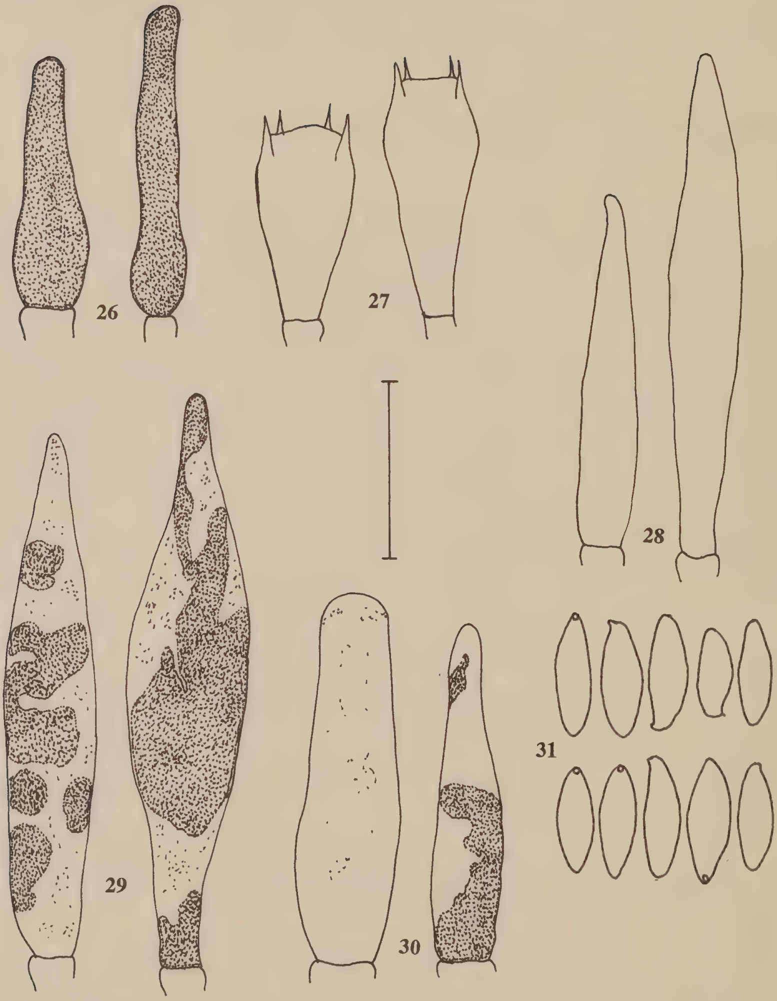
minor, and *T. tabacinus* var. *dubius*, have E values close to this number. Interestingly, the majority of species of *Xanthoconium* Singer species also have spore E values routinely greater than 3.0 , and their cystidial morphology is also similar to *Tylopilus* species (Wolfe, 1987, 1988). Singer (1986) suggested that *Xanthoconium* and *Tylopilus* species are closely related, and that relationship is supported by the data presented here.

Tylopilus tabacinus (Peck) Singer var. ***dubius*** Singer. Mycologia 37: 799. 1945.

Pileus cuticle a loose palisade trichodermium; terminal cells (Fig. 26) 28.6-44.2 x 3.9-6.5 μm (D^M = 33.9 x 5.4 μm), cylindric, equal, tapering distally, ends acute to subtruncate, hyaline in KOH, hyaline to gold in Melzer's reagent. Tube tramal hyphae 2.6-10.4 μm (D^M = 6.6 μm), hyaline in KOH, opaque cream-yellow in Melzer's reagent. Oleiferous hyphae 5.2-9.1 μm (D^M = 7.2 μm), ocher-cream in KOH, dark ocher in Melzer's reagent. Clamp connections absent. Basidia (Fig. 27) 26-41 x 9.8-14.3 μm (D^M = 33.9 x 11.1 μm), clavate, 4-sterigmate, opaque cream in KOH, opaque yellow in Melzer's reagent. Pleurocystidia (Fig. 28) 39-52 x 7.8-9.1 μm (D^M = 43.9 x 8.5 μm), fusoid-ventricose, hyaline in KOH and Melzer's reagent. Pseudocystidia (Fig. 29) 28.6-59.8 x 7.8-13 μm (D^M = 44.2 x 11.4 μm), narrowly to broadly fusoid-ventricose, ocher in KOH, dark ocher-gold in Melzer's reagent, contents irregular to homogeneous, distal end often more darkly staining. Cheilocystidia absent. Stipe dermatocystidia (Fig. 30) 24.7-70.2 x 5.2-10.4 μm (D^M = 48.1 x 7.5 μm), versiform (cylindric, equal, subclavate, clavate, fusoid-ventricose), hyaline or gold in KOH, dark gold in Melzer's reagent; caulobasidia present in caulohymenium. Basidiospores (Fig. 31) 13-15.6 x 3.9-4.6 μm (D^M = 14.2 x 4.5 μm), E = 2.8-3.7 (E^M = 3.1), inequilateral in profile view, elliptical in face view, creamy yellow-green in KOH, opaque in Melzer's reagent, surface smooth, walls continuous without germ pore.

Type Specimen. Lectotype (des. mihi) (FH) - "Fungi Floridani; No. F2904; under *Quercus*; Gainesville, Alachua Co., Fla.; Coll. R. Singer, Det. R. Singer; July 22, 1943." [!]

Singer did not designate a type specimen for this taxon in the protologue (Singer, 1945) or at a later date even though a specimen, F2904, was listed as having been examined (Singer, 1947). Examination of materials from the Farlow Herbarium (FH) revealed that F2904 is labeled as the "type." Singer collected this specimen, considered it the type by virtue of the above label, and therefore, it is designated as the lectotype.



Figures 26-31 - ***Tylopilus tabacinus*** var. ***dubius*** Singer. Fig. 26 - terminal cells of the trichodermium. Fig. 27 - basidia. Fig. 28 - pleurocystidia. Fig. 29 - pseudocystidia. Fig. 30 - stipe dermatocystidia. Fig. 31 - basidiospores. Reference line = 20 μm.

Discussion. Encrusted terminal cells of the trichodermium were not observed in this study even though Singer (1947) implied that some were encrusted (..."microscopical characters as in var. *typicus*"). Studies of the type specimen of *T. tabacinus* var. *tabacinus* (Peck) Singer revealed that the terminal cells of the pileus trichodermium were encrusted (Wolfe, 1981). The terminal cells of the pileus trichodermium of *T. tabacinus* var. *dubius* are not, however, encrusted. Pleurocystidia of *T. tabacinus* var. *tabacinus* were described by Wolfe (1981) as hyaline (pleurocystidia) to yellow (pseudocystidia) in KOH and dark yellow (pleurocystidia) to rust-gold (pseudocystidia) and are similar to the pleurocystidia and pseudocystidia of *T. tabacinus* var. *dubius*. Cheilocystidia are absent in both taxa, and stipe dermatocystidia are longer in *T. tabacinus* var. *dubius*.

Singer (1947) indicated that *T. tabacinus* var. *dubius* was "closer to *T. ferrugineus*" than other varieties of *T. tabacinus*. Halling (1983) studied the lectotype of *Tylopilus ferrugineus* (Frost non-Schaeffer) Singer. He reported that pleurocystidia (pseudocystidia by virtue of the dextrionid reaction) and cheilocystidia are present. Cheilocystidia are absent in *T. tabacinus* var. *dubius*. Terminal cells of the trichodermium of *T. ferrugineus* were described as becoming slowly dextrinoid in Melzer's reagent (Halling, 1983) but in *T. tabacinus* var. *dubius* they are gold in Melzer's reagent. Basidiospores of *T. ferrugineus* are shorter than those of *T. tabacinus* var. *dubius* but their widths are about the same. On the basis of these studies, *T. tabacinus* var. *dubius* is microscopically more similar to *T. tabacinus* var. *tabacinus* than to *T. ferrugineus*.

ACKNOWLEDGEMENTS

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NOTES ON BAMBUSICOLOUS PYRENOMYCETES. Nos. 1–10.

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Abstract

This paper consists of 10 notes on bambusicolous pyrenomycetes. The new genus *Mixtura* O. Eriksson & Yue is described. The following new combinations are proposed: *Mixtura saginata* (H. Sydow) O. Eriksson & Yue (*Leptosphaeria s.*), *Monographella consociata* (Rehm) O. Eriksson & Yue (*Leptosphaeria c.*), *Puttemansia miakei* (Hino & Katum.) O. Eriksson & Yue (*Broomella m.*), *Togninia inconspicua* (Rehm) O. Eriksson & Yue (*Calosphaeria i.*), and *Trematosphaeria crustacea* (Rehm) O. Eriksson & Yue (*Rosellinia c.*). *Uleomyces tapirae* is recorded as new to China. The type material of *Sphaeria weddellii* Mont. is redescribed.

Introduction

There are more than 500 bamboo species in the world, placed in 49 genera in one recent classification of grasses (Clayton & Renvoize 1986), in 60 genera in another (Watson *et al.* 1985), and in 111 genera with 1136 species in a further one (Tzvelev 1989). These systems have obviously evolved independently.

Still another classification is found in Dahlgren *et al.* (1985), but not treating all genera. We have, as a rule, followed the classification proposed by Clayton & Renvoize. More than 500 species of pyrenomycetes have been described from bamboos, but the total number is probably considerably higher as many bamboo genera have never been examined and reported as hosts of fungi.

Many of the bambusicolous pyrenomycetes were described 75 years ago or earlier. The generic concepts were then in many cases very different from the current ones. Many of these old species have never been examined and discussed since they were described. It is necessary to study the types of most of these species and provide new detailed descriptions and illustrations.

The present paper is the first in a series treating bambusicolous pyrenomycetes. They will provide new information on specimens that we have borrowed from various herbaria and on material that we have collected in the field (Yunnan, Hainan, etc.).

Notes

1. Coccodiella arundinariae Hara 1911: (224). – Fig.: 1.
≡ *Coccostromopsis arundinariae* (Hara) Teng 1938: 255. *Syn. cet.*: see Katumoto 1968: 280.

Teleomorph. See Katumoto 1968: 277.

Anamorph: unknown.

Habitat: on living leaves of bamboos (*Sasa*, *Arundinaria*, etc.).

Distribution: Asia (China, Japan).

Material studied: Japan, Honshu, Mino Prov., Kawauyemura, on *Sasa paniculata*, 1912, leg K. Hara (S).

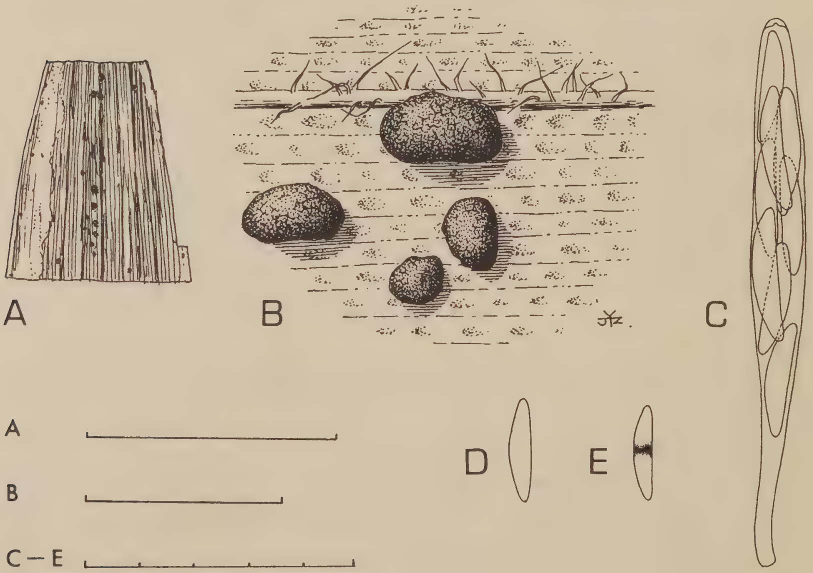

Fig. 1. *Coccodiella arundinariae*. (A, B) Stromata on a leaf. (C) Ascus. (D) Ascospore. (E) Ditto in cotton blue (non-septate!). – Scales: (A) 50 mm, (B) 2 mm, (C–E) 50 µm. – Material: Hara 1912 (S)

Discussion. *Coccodiella arundinariae* Hara is a stromatic pyrenomycete on bamboo leaves. The stromata are superficial and originate from an innate hypostroma. They are cushion-like, often a little elongated and may be more than 1 mm long. They contain many immersed perithecia. Katumoto (1968: 277) found that the asci are unitunicate and considered that the genus should be referred to the Polystigmataceae and not the Dothideaceae. This is in agreement with the material that we have examined. The asci are slightly thickened at the apex and usually with a small ocular chamber. The genus belongs in the Phyllachoraceae (syn. Polystigmataceae). Hara (1911: 224) described the spores as 1-septate, but later (1913) corrected that to non-septate, which was corroborated by Katumoto (1968). We have treated spores with KOH as well as NaClO and seen a septum-like structure in one spore only, but it seems that the spores normally are non-septate in this species.

2. Mixtura O. Eriksson & Yue, gen. nov.

Thallus in foliis vivis perthophyticus; ascomata in maculis dispersa, in mesophyllo innata, sub-globosa vel late ellipsoidea, pseudostiolata, paries ascomatis tenuitunicatis, ex textura angulari, flava - ochracea. Pseudoparaphyses sat sparsae. Asci pauci, bitunicati, ellipsoidei, sessiles vel indistincte stipitati, apicaliter valde incrassati, 8-spori. Ascosporae ±tetraseriatae, fusoideae, leniter curvatae, pluriseptatae, cellulis medianis longioribus, non vel leniter constrictae, olivaceo-brunneae, cellulis terminalibus dilutioribus; stratum perisporii mucosum.

Typus: *Mixtura saginata* (H. Sydow) O. Eriksson & Yue.

Etym.: the name refers to the mixture of features, seen in different unrelated genera.

Thallus perthophytic in living leaves; ascomata scattered in spots, immersed in mesophyll, sub-globose or broadly ellipsoidal, pseudostiolate, thin-walled, cells in textura angularis, yellowish to yellowish brown. Hamathecium of pseudoparaphyses. Asci few, bitunicate, ellipsoidal, sessile or short-stalked; apically strongly thickened, 8-spored. Ascospores ±tetraseriate, fusiform, slightly bent, with several transverse septa (median cells longer), not constricted, or slightly constricted at primary septum, thick-walled and olivaceous brown, but thin-walled and pale at the ends, with a thin perispore.

Type species: *Mixtura saginata* (H. Sydow) O. Eriksson & Yue.

Mixtura saginata (H. Sydow) O. Eriksson & Yue, comb. nov. - Fig.: 2.
≡ *Leptosphaeria saginata* H. Sydow, *Annales Mycologici* 37: 376 (1939).

Teleomorph. *Thallus* producing amphigenous, elongated yellowish spots with brown margin in living leaves; spots up to 100 x 3-6 mm (Sydow, l.c.). *Ascomata* scattered in spots, usually separated, immersed, breaking with ostiolar region through the epidermis on the lower side of the leaf and visible through some narrow cracks, reaching also the epidermis on the opposite side and visible as a brownish spot; wall thin, of textura angularis, yellowish to yellowish brown.

Hamathecium of comparatively few pseudoparaphyses; cells c. 10–12 x 6 µm, with most of the plasmatic contents near septa. *Asci* few (c. 10), c. 110 x 56 µm (Fig. 2C; 100–125 x 55–70 µm: Sydow, l.c.), sac-like, sessile or with a short stipe; ectotunica thin; endotunica c. 2 µm thick, but in apical part gradually thickened to c. 10 µm, without laminations and ring structures: with 8, ±tetraseriate ascospores. *Ascospores* c. 75–90 x 18–20 µm (excl. perispore), fusiform, slightly bent, (5–) 7-septate, young spores hyaline or very pale brown with foam-like sporoplast, mature spores olivaceous brown, with hyaline, needle-like crystals in some or all segments; wall with a c. 1 µm thick, pigmented layer, in some spores missing at the ends and inner wall layer bulging out here with a light-reflecting end, innermost layer thin, hyaline, lining the sporoplasts, perispore thin.

Anamorph: unknown.

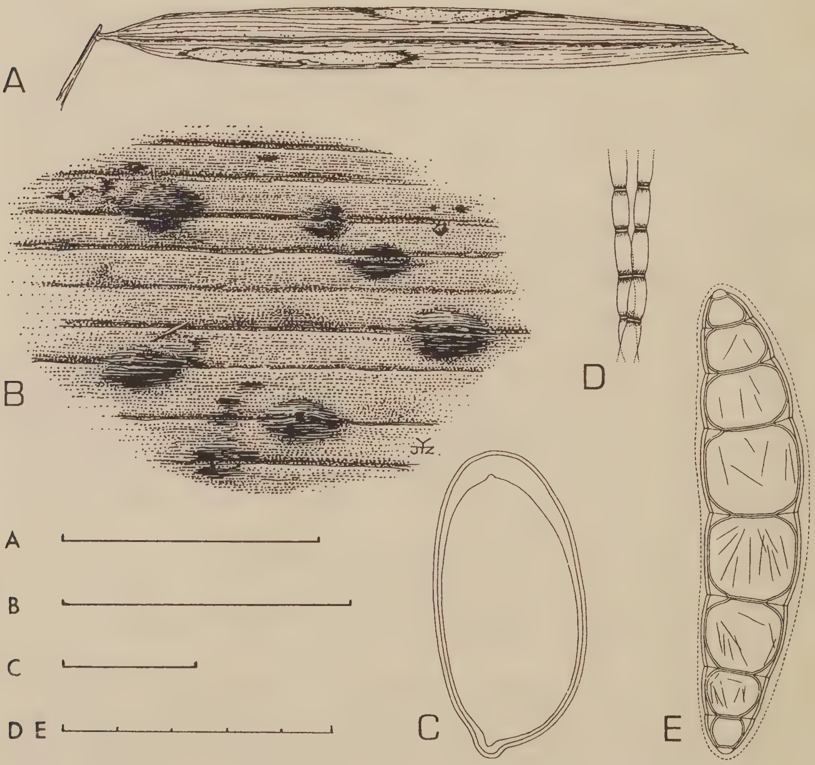

Fig. 2. *Mixtura saginata*. (A,B) Ascomata in a *Chusquea* leaf. (C) Ascus with spores (not indicated). (D) Pseudoparaphyses. (E) Ascospore. – Scales: (A) 50 mm. (B) 1 mm. (C) 50 µm. (D,E) 50 µm. – Material: H. Sydow, Fungi exot. exs. no. 1197 (S, type).

Habitat: leaves of *Chusquea serrulata*.

Distribution: South America (Ecuador).

Material studied: Ecuador, Tungurahua Prov., Hacienda San Antonio at Baños, on *Chusquea serrulata*, 9.i.1938, leg. H. Sydow [Sydow, Fungi exot. exs. 1197] (S; herein designated the lectotype), [Reliquiae Petrakianae 627] (S, isolectotype).

Discussion. *Leptosphaeria saginata* shows a remarkable mixture of characteristics. The spots on living leaves of *Chusquea serrulata* recall those caused by bambusicolous *Mycosphaerella* species. Under the microscope the thin-walled ascomata are similar to those in *Phaeosphaeria*, but are more yellowish brown than is usually the case in that genus. The hamathecium of pseudoparaphyses that are not enclosed in a gel are much more distinct than in *Phaeosphaeria*. In the type species, *P. oryzae* Miyake, the hamathecium is very difficult to observe. In *L. saginata* the comparatively sparse pseudoparaphyses have the plasmatic contents concentrated towards the septa as is seen in some other genera, e.g. *Coccoidea* (see Eriksson 1981: 46). The asci are ellipsoidal and apically thick-walled as in some *Wettsteinina* species, but more ellipsoidal in shape. The fusiform ascospores, which are olivaceous brown and rather thick-walled, but thin-walled and much paler at the end cells, recall some *Trematosphaeria* species. *Leptosphaeria saginata* can not be referred to any of these genera or any other genus, so the new genus *Mixtura* was erected to accommodate this species.

The position of the new genus *Mixtura* is a little uncertain, but if the structure of the ascomata and the hamathecium is given most weight, the genus can provisionally be referred to the Phaeosphaeriaceae.

3. Monographella consociata (Rehm) O. Eriksson & Yue, comb. nov. - Fig.: 3.

≡ *Leptosphaeria consociata* Rehm in *Hedwigia* 35: (149), 1896.

Teleomorph. *Thallus* causing small necrotic spots in living leaves of *Chusquea* sp., many with sporodochia of *Microdochium* type. *Ascomata* single or 2-3 aggregated, often (always?) originating in sporodochia, c. 110 μm diam (to 300 μm fide Rehm l.c.), subglobose, thin-walled, light brown, ostiole c. 20 μm, periphysate. *Hamathecium* of numerous paraphyses between asci and periphyses in the ostiole. *Asci* rather numerous, probably up to c. 120 x 25 μm (90-100 x 21 μm, fide Rehm l.c.), sac-like with a short, ±bent stipe, unitunicate, but with a low endotunica at the apex, with a simple, I+ blue, c. 4 μm wide, hanging ring; with 8, biseriate ascospores. *Ascospores* c. 32-38 x 8-11 μm, fusiform, symmetric or distinctly narrower at the lower end, usually (3-)4-5(-6)-septate, hyaline, without gelatinous perispore.

Anamorph: in many spots, seen as short, elongated, light-coloured, cushion-like sporodochia of *Microdochium* type, at first covered by epidermis, then erumpent through a slit; conidiophores, short, sparsely branched, with lateral or apical conidiogenous cells; no mature conidia seen, but only developing ones.

Habitat: leaves of *Chusquea* sp.

Distribution: South America (Ecuador).

Material studied: Ecuador, Pichincha Prov., San Jorge, on the upper side of *Chusquea* leaves, vii.1892, leg. G. von Lagerheim [Rehm, Ascomyceten no. 1190]

(S, herein designated the lectotype).

Discussion. Rehm (1896: (149)) pointed out in the protologue of *Leptosphaeria consociata* that this species differs from other *Leptosphaeria* species in the I+ ascus pore. However, there are no true *Leptosphaeria* species with an I+ ring in the ascus top. We examined type material and found that *L. consociata* is a typical member of *Monographella* Petrak (Amphisphaeriaceae s.lat.) and has to be called *Monographella consociata* (Rehm) O. Eriksson & Yue.

Rehm distributed two collections under the name of *Leptosphaeria consociata* Rehm in his exsiccata "Ascomyceten", the type on bamboo leaves from Ecuador as no. 1190 and another fungus on stromata of *Epichloe typhina* on *Glyceria nervata* from Canada as no. 1994. The two fungi have somewhat similar ascospores, but the fungus on *Epichloe* has I− asci and belongs to *Phaeosphaeria*

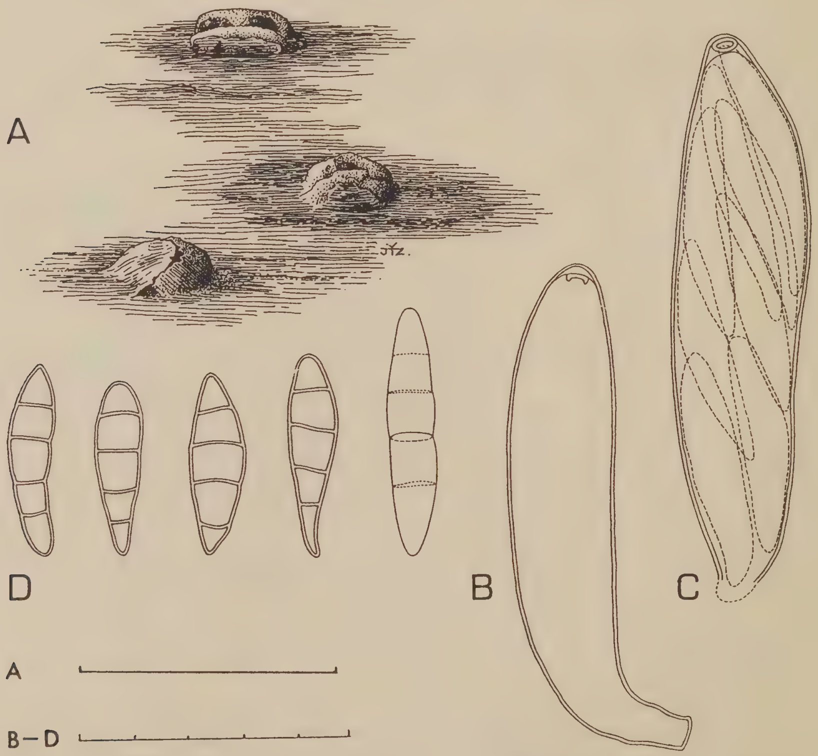

Fig. 3. *Monographella consociata*. (A) *Microdochium* sporodochia with ascomata of *Monographella consociata* (three ones partly seen). (B) Ascus (empty). (C) Ascus, outline of spores indicated, base hidden by fungal tissue. (D) Ascospores. – Scales: (A) 2mm. (B–D) 50 µm. – Material: Rehm, Ascomyceten, no. 1190 (S, type).

associata (Rehm) O. Eriksson (see 1967: 412).

Monographella consociata differs from other species in the genus in the generally 4–5–septate, larger ascospores. All other species have usually either 1– or 3–septate spores (Müller & Samuels 1985: 115). It resembles the other species in having a *Microdochium* state, but no mature conidia were found in the type collection.

We found numerous colonies of *Antennularia chusqueae* (Rehm) Farr in the envelopes with type specimens of *Leptosphaeria consociata*. It was described as *Asteridium chusqueae* by Rehm (1896: (150)) and distributed as no. 1195 in his exsiccata. The collecting dates are the same and the type materials of the two species certainly are parts of one and the same collection. It seems that *Antennularia chusqueae* is always associated with the sporodochia of *Monographella consociata* (incorrectly interpreted as the hypostroma of *A. chusqueae* by Farr, 1966: 223), and it is probably obligately fungicolous on that species.

4. **Phaeosphaeria bambusae** Miyake & Hara 1910: (340). – Fig.: 4.

≡ *Leptosphaerella bambusae* (Miyake & Hara) Miyake & Hara 1913: (249).
≡ *Leptosphaeria bambusae* (Miyake & Hara) Sacc. in Sacc. & Trotter 1928: 995 (non Rolland 1896).
≡ *Trematosphaerella bambusae* (Miyake & Hara) Hino & Katumoto 1961: 160.

Teleomorph. *Thallus* parasitic in bamboo leaves, inconspicuous, but infection visible as a brown spot, that gradually turns greyish, with a brown margin, when it spreads over the whole or most parts of the infested leaves. *Ascomata* very numerous in spots of dead tissue in living leaves, subglobose or more flattened, c. 200–280 μm across, scattered, immersed, with a small, lysigenous pore; wall thin, of reddish brown, angular cells. *Hamathecium* not visible in the material (present in immature ascomata and deliquescing early?). *Asci* clavate (68.4–91.1 x 19.5–28.6 μm, acc. to Hino & Katumoto 1961: 160; all asci seen by us broken), endotunica strongly swelling in broken asci (Congo red), no apical ring visible. *Ascospores* 24–29 x 8–9.5 μm, broadly fusiform with rounded ends, inequilateral, (1–2–)3–septate, broadest at the segment above the primary septum, slightly constricted at septa, pale brown, smooth, without a distinct perispore.

Anamorph: a "*Phyllosticta* stage" was described by Tanaka (1922: 86) as follows: "Pycnidia immersed, globose or depressed–globose, ostiolate at the apex, 100–140 x 70–100 μ; pycnospores ooze from the pycnidial opening when mature, ellipsoid or cylindrical, hyaline, 2–2.5 x 1.1–3 μ".

Habitat: living leaves of *Arundinaria simonii* (*Pleioblastus s.*), and several other bamboo species (cf. Hino & Katumoto 1961: 160).

Distribution: Asia (China, Japan), Africa.

Material studied: Japan, Honshû, Musasi Prov., Naka–sibuya near Tokyo, in living leaves of *Arundinaria simonii*, 7.VII.1910, leg. ? (S).

Discussion. The original description of *Phaeosphaeria bambusae* was in Japanese. Tanaka (1922: 86) provided a description in English of the teleomorph and of a *Phyllosticta* stage. This parasite in dead spots on leaves of *Arundinaria simonii* is a typical *Phaeosphaeria* species, causing similar symptoms to those of the type species of *Phaeosphaeria*, *P. oryzae* Miyake, on *Oryza sativa*. That species has also a *Phyllosticta* stage. The small ascomata are very similar in the two species, with a thin, reddish brown wall.

The material of *P. bambusae*, that we have studied was probably sent by Hara to Sydow. It is, however, not from any of the localities cited by Tanaka (l.c.). It is old and the asci are difficult to study, but with chlorazol black or Congo red the endotunica can be seen in opened, empty asci. The ascospores are 3–septate and light brown. They are distinctly larger (24–29 x 8–9.5 μm) than the spores of *P. oryzae* (17 x 4 μm).

Leuchtmann (1984) did not discuss this species in his extensive treatise of *Phaeosphaeria* and some other phragmosporous bitunicates. Neither the type nor original description was seen by Shoemaker & Babcock (1989) either, so they excluded the species from *Phaeosphaeria*. As pointed out by Leuchtmann, the pseudoparaphyses are sometimes very sparse. This may be the case in *P. bambusae*. Tanaka (l.c.) and Hino & Katumoto (l.c.) report that the species is "aparaphysate". We have not seen any traces of a hamathecium but it will be necessary to study very young ascomata in order to establish whether hamathecial tissues are missing from the very beginning.

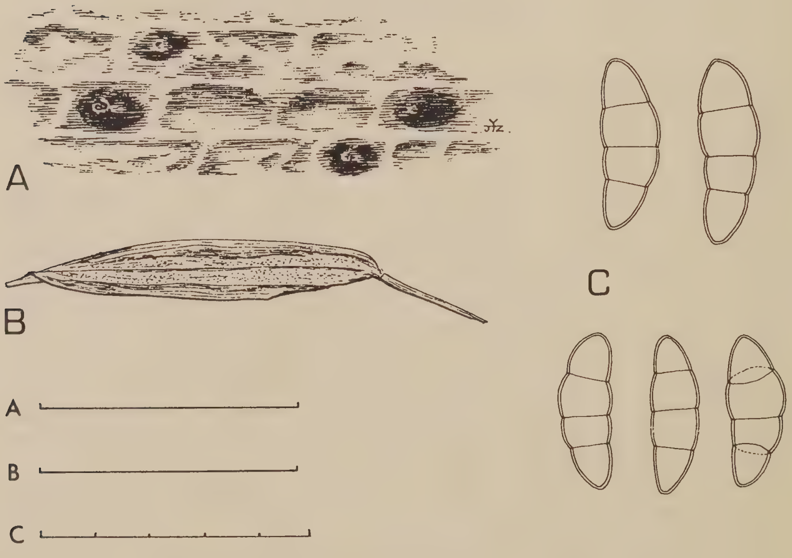

Fig. 4. *Phaeosphaeria bambusae*. (A, B) Ascomata in a leaf. (C) Ascospores. – Scales: (A) 2 mm, (B) 50 mm (C) 50 μm. – Material: Japan, Naka–sibuya (S, type).

5. Puttemansia miakei (Hino & Katum.) O. Eriksson & Yue, comb. nov. – Fig.: 5.

≡ *Broomella miakei* Hino & Katumoto, *Bull. Fac. Agric. Yamaguti Univ.* 6: 43 (1955).

Teleomorph. *Thallus* in bamboo leaves, innate parts inconspicuous, producing superficial, shield-like stromata, which are gradually thinner towards the margin, and consist of radiating hyphae with thick-walled, pale brown cells, paler to hyaline towards the margin. *Ascomata* arising singly to a few in central parts of the stromata, subglobose, up to c. 350 µm wide, reddish brown and collapsed into cup-shape when dry, smooth, with a small central ostiole; wall c. 30–35 µm thick, continuous with the subtending stromal tissue, of several layers of angular, thick-walled cells, light brown in outer parts, hyaline in inner parts. *Hamathecium* of numerous, anastomosing, c. 2 µm wide pseudoparaphyses, with asci filling the locule also in dry ascomata. *Asci* "117.4–156.5 x 13.0–17.8" µm (Hino & Katumoto 1955: 43), cylindric clavate, bitunicate, short-stalked, I–; ectotunica thin; endotunica thickened towards the apex, with a small ocular chamber, without ring structures; with 8, overlapping biseriate ascospores. *Ascospores* 45–60 x 5–7 µm ("17–32 x 4.5–6" µm, Hino & Katumoto 1955: 43), narrowly fusiform, lower hemispore with longer and more tapering end, 4–5(–7)-septate, at the 4-septate stage with long central segment, septa thin, wall very thin, smooth, hyaline.

Anamorph: conidiophores short, moniliform, c. 3–4 µm wide, in a dense pallisade on the lower surface of stromata, except for the thinner marginal parts, producing tetraradiate, holoblastic conidia of the *Tetracrium*-type; basal arm c. 9 x 4 µm, ellipsoidal, apically with 3 radiating arms, which are short and one-celled with broadly rounded ends in young conidia, but in mature conidia c. 60 x 4 µm, broadest c. 20 µm from the constriction at the point of attachment, tapered towards both ends, 2-septate, apical cell prolonged.

Habitat: on living leaves of bamboos.

Distribution: Asia (Japan).

Material studied: Japan, Honshu, Nagato Prov., Hukuga in Abu-tyo, on leaves of *Sasa tyugokensis*, 2.iv.1955, leg. N. Miake (**IMI** 63383, isotype).

Discussion. *Broomella miakei* resembles *Uredinophila erinacea* (Rehm) Rossman, an uredinicolous member of the Tubeufiaceae on bamboos. They are certainly closely related, but *B. miakei* obviously feeds directly on the bamboo, as stated already by Hino & Katumoto in the protologue. Locules are enclosed separately in one or several cushion-like, perithecioid projections from the central parts or small superficial shield-like stromata. This refers the species to the genus *Puttemansia* P. Henn., but it is not conspecific with any of the 6 species accepted by Rossman (1987: 30). Therefore, the new combination into *Puttemansia miakei* is proposed.

Puttemansia miakei seems to be most closely related to *P. rickiana* (Sacc. & H. Sydow) Petrak and *P. stromatica* (Cooke) Rossman (see Rossman 1987: 30–37), but does not seem to be associated with any other fungus on the leaves as these two species are, and differs in the shape, septation and size of the ascospores. The ascospores in the isotype material of *P. miakei* examined by us agree with the protologue, except for being considerably larger.

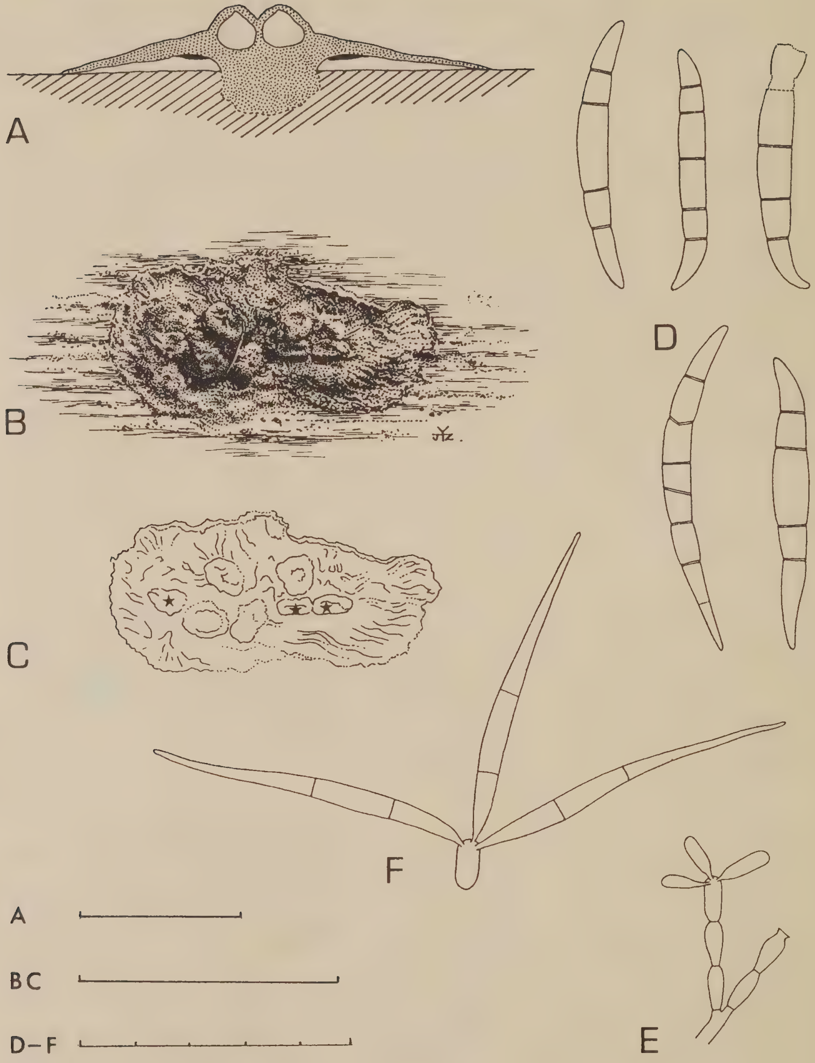

Fig. 5. *Puttemansia miakei.* (A) Schematical sketch of a stroma with locules and conidiogenous part (indicated by thick, black line). (B) Stroma with several ascomata on a leaf. (C) Ditto schematical. * = host tissue bulging up through holes in the stroma. (D) Ascospores. Note, third spore broken. (E) Young conidium of three radiate arms and a basal cell on a conidiophore. (F) Mature conidium. – Scales: (A) c. 1 mm. (B, C) 2 mm. (D–F) 50 µm. – Material: IMI 63383, isotype.

The most important difference against the other species, however, is the structure of the anamorph. Conidia are produced on the lower surface of the shield-like stromata in great abundance (Fig. 5A). They are tetraradiate with 3 long arms on a short ellipsoidal basal cell. Young conidia have one-celled arms with broadly rounded ends (Fig. 5E). Mature conidia has 2-septate upper arms, each tapered towards both ends, broadest towards the base, but constricted near the point of attachment (Fig. 5F). The conidia are correctly illustrated by Hino & Katumoto (l.c.). Also Pirozynski (1977: Fig. 3G) has an illustration that fits this conidium, but he considered it the conidium of *Podonectria bambusicola* (Rehm) Piroz. (basionym *Trichonectria bambusicola* Rehm). According to Rossman (1987: 43), that name is a synonym of *Uredinophila erinacea*, a species without any known anamorph. We have examined original material of *T. bambusicola* and not found any tetraradiate conidia, but sometimes several species belonging to the Tubeufiaceae are present in the same material, and stromata of *P. miakei* may have been present in the material studied by Pirozynski. There is also the possibility that another species (? *T. bambusicola*), in fact, has a similar type of conidium.

6. "Sphaeria weddellii Mont." 1856: 372. – Fig.: 6.
≡ *Leptosphaeria weddellii* (Mont.) Sacc. 1883: 86.

Teleomorph. *Thallus* in sori of a hyphomycete (conidia ±globose, dark brown, each with one pore, resembling a Munk pore), covered by the epidermis, that finally bursts and the parts covering the ascomata remaining as a cracked shield or peeled off; a ±distinct subiculum present. *Ascomata* subglobose, aggregated in small groups, usually ±obliquely inserted and laterally somewhat compressed, breaking through cracks in the epidermis with short, ±convergent beaks; cells in the outer layers of the ascomata with thick and dark-coloured walls, innermost layers paler and with thinner walls; ascomata hollow when dry. *Hamathecium* lacking. *Asci* subcylindrical, c. 90–120 x 8–9 µm, very thin-walled, with a small, thin, I–, CR– ring; with 8, uniseriate ascospores. *Ascospores* c. 15–17 x 6 µm, elliopsoidal, inequilateral, non-septate or finally with 3 septa, hyaline, with one large irregular oil body or usually 2–4 oil globules; without distinct perispore.

Anamorph: unknown.

Habitat: culms of a tall grass, prob. a bamboo.

Distribution: South America (Bolivia).

Material studied: Bolivia, "prov. de Larecaja et Caupolican (vallées entre Tipoani et Apolobamba) Mai 1847. M. H. Alg. Weddell 1848" (**PC**, holotype).

Discussion. Montagne (1856: 373) stated that "Cette Sphérie ressemble à quelques autres, et entre autres aux *S. stegophora*, *S. clivulosa* et *S. phaselina* de ma Cryptogamie de la Guayane (Sylloge, p. 239), surtout à la première...". *Sphaeria stegophora* Mont. and *S. clivulosa* Mont. were transferred to *Anthostomella* by Saccardo (1882: 291, 283 resp.) and *S. phaselina* Mont. to *Eutypa* (1882: 179), in all three cases species with non-septate spores. *Sphaeria weddellii* Mont., however, Saccardo (1883: 86) referred to *Leptosphaeria*, as Montagne had described the spores as "ellipsoideis, transverse triseptatis".

The type material consists of four pieces of a grass culm. Four fungi could be found. One of them, an *Anthostomella* species, is immersed and only the ostioles are visible as small dark spots. A second fungus has also immersed, scattered ascomata and is an *Amphisphaeria* species with striated, 1–septate ascospores and asci with I+ blue ring. A third fungus is a hyphomycete (cf. *Arthrinium*) with old ±globose, dark brown conidia with one Munk pore each. The fourth fungus develops in the sori of this hyphomycete. It agrees with the description of *Sphaeria weddellii*, except for most spores are non–septate and not 3–septate as given by Montagne. They contain one large irregular oil body or 2–4 smaller, globose ones, which may look like cells separated by indistinct septa. A few spores were, in fact divided by 1–3 septa, and it is probable that the fungus is not quite mature. However, in one slide it was found that another fungus is intermixed. It seems to have smaller ascomata with hamathecium and spores with 3 narrow, irregular, indistinct septa. Montagne may have seen spores of this fungus, which however, most probably is not the fungus he intended with his description. It is more likely that he interpreted the oil globules as cells in the fungus that dominates in the collection or that he found ascomata with mature spores. Anyhow, most probably he based his description of *S. weddellii* on this fungus.

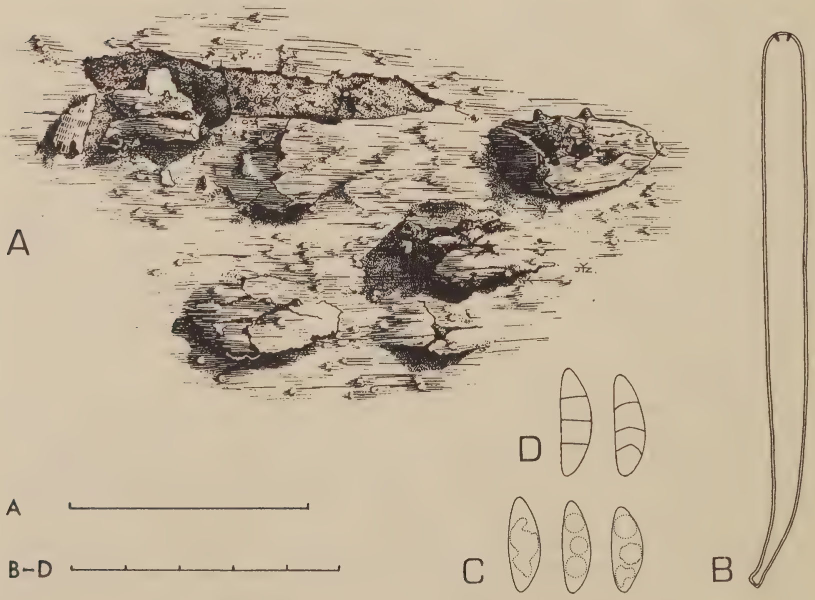

Fig. 6. "*Sphaeria weddellii*". (A) Ascomata. (B) Ascus with immature spores (not indicated). (C) Ascospores, prob. immature. (D) Ascospores, prob. outside the ascomata and over–ripe.– Scales: (A) 2 mm. (B–D) 50 µm. – Material: Weddell 1848 (**PC**, type).

It has not been possible to examine this species adequately, as the type material is old and sparse. It is in any case not a *Leptosphaeria* species. The fungus is probably a member of Diaporthales. It agrees with *Cryptosporella* in gross morphology, but the asci are cylindrical and not clavate as in the type species, *C. hypodermia* (Fr.) Sacc. Therefore, no transfer is made until material with spores and asci in good condition is available. The fungus is rather characteristic and the informations about the collecting area rather informative, although the material was collected as early as 1847-8, so there is the possibility to find more material of it.

We keep the name *Sphaeria weddellii* for this fungus until a transfer to *Cryptosporella* or some genus can be made. It is not conspecific with *Cryptosporella bambusicola* Hino & Katum. (1958: 905); that has clavate asci and much smaller ascospores (5.5--6 x 3-3.5 µm). No other species in the genus are described from bamboos.

7. Togninia inconspicua (Rehm) Yue & O.Eriksson comb. nov. - Fig.: 7.
≡ *Calosphaeria Togninia inconspicua* Rehm, *Leafl. Philipp. Bot.* 6: 2213, 1914.
≡ *Erostella inconspicua* (Rehm) Sacc. 1928: 709.
= *Nitschkea bambusarum* Rehm, 1916: 2956.

Teleomorph. *Thallus* subcorticolous on bamboo culms, inconspicuous. *Ascomata* densely aggregated, subepidermal, erumpent collectively (in holotype of *Calosphaeria inconspicua*) or remaining immersed (in holotype of *Nitschkea bambusarum*), spherical, c. 100-150 µm wide, with a short, oblique beak, pore c. 12-15 µm; ascomal wall dark reddish brown to opaque under the microscope, cells thick-walled of irregular shape. *Hamathecium* absent. *Asci* c. 25-28 x 6-7 µm, clavate, without distinct stalk, originating in clusters on proliferating ascogeneous hyphae, 8-spored. *Ascospores* (5.5-)8-10(-11) x 1.5-2 µm, allantoid, hyaline, non-septate, with one small oil drop at each end.

Anamorph: unknown.

Habitat: culms of *Bambusa vulgaris* and *Gigantochloa schrebneriana*.

Distribution: Asia (Philippines).

Material studied: Philippines, Luzon, Laguna Prov., Los Baños, on *Gigantochloa schrebneriana*, 10.ix.1913, leg. M.B. Raimundo, no. 1698a (S, holotype of *Calosphaeria inconspicua*), "12. *Calosphaeria inconspicua* Rehm n.sp.", Mt. Maquiling, near Los Baños, Herb. C.F. Baker (S; prob. a part of Raimundo no. 1698); ditto, on *Bambusa vulgaris*, 20.x.1913, leg. S.A. Reyes (S, holotype of *Nitschkea bambusarum*).

Discussion. Barr (1985: 562), in a survey of the order Calosphaeriales, accepted one species in the genus *Togninia* Berl., *T. minima* (Tul. & C. Tul.) Berl. The genus differs from other genera in the order by sessile, oblong, octosporous asci. She stated that other species that Berlese (1900) "illustrated in *Togninia* have clavate and stipitate asci and do not belong within the genus as it is typified". The ascospores of the single species were described by Barr (l.c.) as "hyaline, allantoid or oblong, one-celled ... 3-5.5 x 1-2 µm". Although the ascomata of *Calosphaeria inconspicua* have a slightly lateral beak and clavate asci, the species may be accepted in *Togninia*. The spores are twice as long as in *T. minima*. They are slightly curved and contain a small oil drop at each end.

Rehm (l.c.) described the new species "*Calosphaeria Togninia inconspicua* Rehm" in the genus "*Calosphaeria* Tul.", which probably means that he considered *Togninia* a subgenus of *Calosphaeria*. Therefore, a new combination was necessary.

Both the type collection of *Calosphaeria inconspicua* (no. 1698) and the other collection (no. 12) contain mature ascomata. The holotype of *Nitschkea bambusarum* Rehm agrees in every respect with *C. inconspicua*, except for ascomata being usually immersed and not collectively erumpent. Fitzpatrick (1923: 37) examined original material of *N. bambusarum* and found that it was not a member of "Nitschkieae", because "the perithecia are spheric, possess a prominent beak, and do not become cupulate". He considered it of doubtful relationships. There is no label signed by him in the Stockholm collection. Nannfeldt (1975: 61) saw an isotype collection in W and stated that it is "a unitunicate pyrenomycete but totally alien to the Coronophorales".

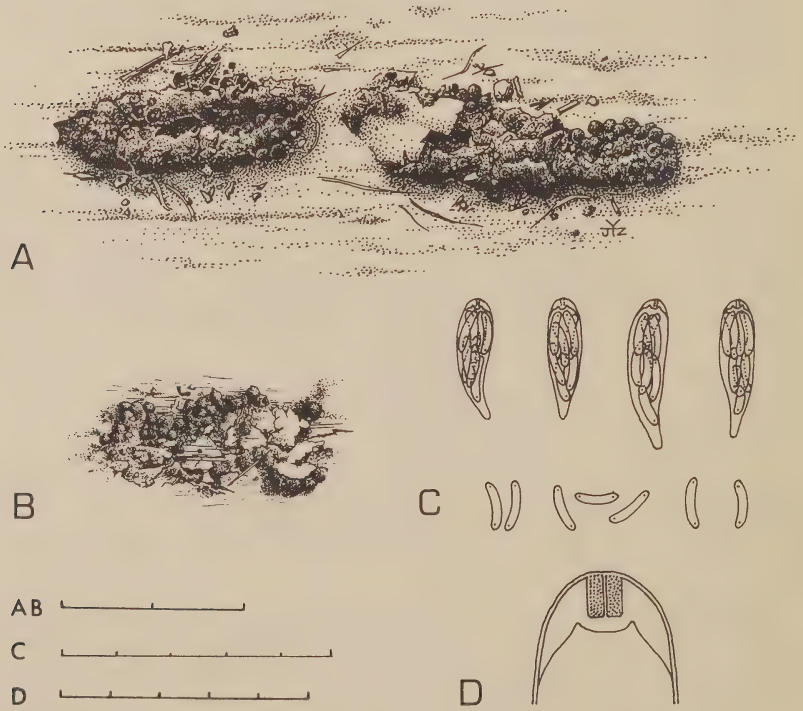

Fig. 7. *Togninia inconspicua*. (A, B) Ascomata. (C) Asci and ascospores. (D) Ascus top with I− ring. − Scales: (A,B) = 2 mm, (C) = 50 µm, (D) = 10 µm. − Material: (A) Type of *Nitschkea bambusarum*, S. (B−D) Type of *Calosphaeria inconspicua*, S.

8. Trematosphaeria crustacea (Rehm) O. Eriksson & Yue, comb.nov. – Fig.: 8.
≡ *Rosellinia crustacea* Rehm, *Leafl. Philipp. Bot.* 8: 2941 (1916).

Teleomorph. *Thallus* parasitic on bamboo culms, consisting of a c. 0.3–0.5 mm thick, subepidermal pseudostromatic crust of almost not at all distorted host cells ±filled with dark brown hyphae; a thinner, pulveraceous, dark brown crust ±covers ascomata and surrounding surfaces of the epidermis. *Ascomata* densely aggregated, immersed, elevating the epidermis and the c. 250 µm thick covering pseudostromatical tissue to form c. 2–2.5 mm wide and 1–1.2 mm high, conical or more rounded elevations (often rupturing stellately and the thick, rounded, pseudostromatic flaps forming a crown around a central opening); no true ascomal wall remaining, but one hemispheric locule, c. 1 mm wide or more, in each elevation. *Hamathecium* not observed. *Asci* not observed. *Ascospores* c. 75–85 x 24–26 µm, ellipsoidal or more fusiform, usually somewhat inequilateral, with one median, thick, dark brown euseptum (NaClO separates the hemispores almost completely after some minutes), sometimes with a faint septum in one or both

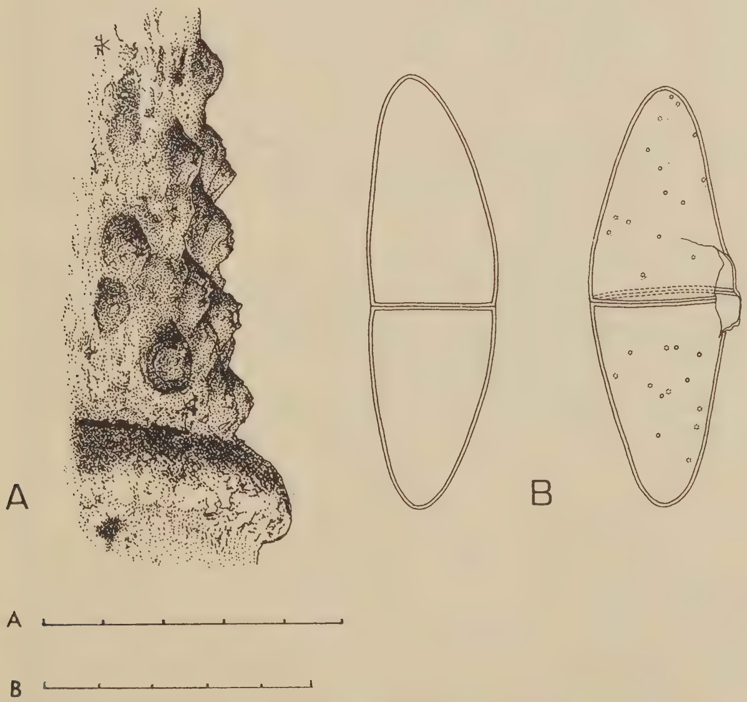

Fig. 8. *Trematosphaeria crustacea.* (A) Ascomata on a bamboo culm. (B) Ascospores (pores indicated in the broken spore). – Scales: (A) 10 mm. (B) 50 µm. Material: Baker no. 3372 (S, holotype).

hemispores, cutting off a segment of about half the length of central segments, not constricted at septa or only a little so at the primary septum; wall double, of an outer, smooth, dark brown layer with numerous, irregularly scattered or some linearly arranged pores, and an inner, probably colored, thin layer that is missing at the ends (therefore, wall somewhat paler here; the extension of the inner layer distinctly seen in NaClO mounts with strongly swelling wall layers); no perispore observed.

Anamorph: not observed.

Habitat: living culms of *Schizostachyum* sp.

Distribution: Asia (Philippines).

Material studied: Philippines, Luzon, Los Baños, on living culm of *Schizostachyum* sp., 10.v.1914, leg. S.A. Reyes 3372 (S, holotype).

Discussion. This characteristic parasite on bamboo culms seems to have been collected only once, and in an over-ripe stage. Rehm (1916: 2941) did not see any asci and the fact that he incorrectly described the ascospores as non-septate explains why he referred the species to *Rosellinia*. However, the spores are 1(-3)-septate, and this species is not close to *Rosellinia* and other Xylariaceae, but to the Melanommataceae. There is no genus that perfectly fits this fungus. The thick pseudostromatic layer covering the ascomata is a distinct feature and the large, dark brown spores, paler at the ends, indicate that it may be close to some species that have been placed in *Trematosphaeria*, e.g. *T. perrumpens* Samuels & E. Müller (1978: 151). Boise (1983: 666) accepted a separate genus, *Byssothecium* Fuckel, for *Trematosphaeria* species with a hamathecium of pseudoparaphyses and not paraphysoids. We do not know, however, what type of hamathecium the bambusicolous species has, as the ascomata are empty, but provisionally it may be included in *Trematosphaeria*.

The minute pores in the spore wall are remarkable and were naturally overlooked by Rehm. Similar small pores were discovered in *Lasiosphaeriopsis stereocaulicola* (Nitschkeaceae, Sordariales) by Eriksson and Santesson (1986: 569, Fig. 5, SEM graph), in that case, as it seems, one pore/cell in the (2-)4-5(-9)-septate spores. In *Trematosphaeria crustacea*, there are a lots of minute pores in each cell in the spore. In some spores they are not easily seen, but are best studied in lactophenol mounts and with perfectly adjusted light in the microscope. Oil immersion is not needed for observing the pores.

9. **Uleomyces tapirae** (F.L. Stev. & Weedon) Petrak 1927: 304. - Fig.: 9.

Teleomorph: see Stevens & Weedon 1923: 197.

Anamorph: unknown.

Habitat: on *Phyllachora* species on various hosts, also bamboos.

Distribution: tropical America and Asia (China).

Material studied: China, Hainan, Ai County, Nan Tian Farm, Red Flag District, beside a stream, on bamboo leaves, 14.i.1987, leg. Yue J.Z., Tian J.X. & O. Eriksson 870114-9e (HMAS, UME).

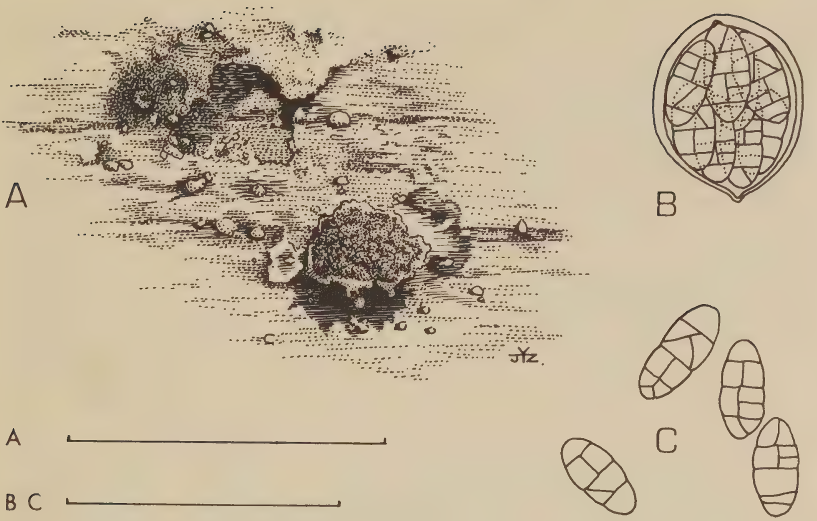

Fig. 9. *Uleomyces tapirae*. (A) Ascoma of *U. tapirae* to the right and of *Phyllachora* sp. to the left. (B) Ascus. (C) Ascospores. – Scales: (A) 1 mm. (B,C) 50 µm. – Material: Yue *et al.* 870114–9e (**HMAS**).

Discussion. Strictly speaking, *Uleomyces tapirae* is not bambusicolous, but confined to *Phyllachora* species on various hosts. The host fungus may be completely consumed and it may seem that *U. tapirae* lives directly on the vascular plant.

Uleomyces tapirae is previously only reported from tropical America (see von Arx 1963: 455). The collection studied here is the first record of the species from Asia. The *Phyllachora* species has spores measuring about 16–17 x 6 µm, which is the approximate size in *P. phyllostachydis* Hara.

10. Uredinophila erinacea (Rehm) Rossman 1987: 43. – Fig.: 10.
≡ *Ophionectria erinacea* Rehm 1913: 182.
= *Trichonectria bambusicola* Rehm 1914: 2226.

Teleomorph: see Rossman l.c.
Anamorph: unknown, but see below.
Distribution: Asia (Japan, Philippines and Sri Lanka; Rossman 1987: 45).
Material studied: Philippines, Luzon, Laguna Prov., Los Baños, in rust sori on leaves of *Bambusa* sp., 12.ix.1912, leg. C.F. Baker 36 (S, isolectotype of

Ophionectria erinacea designated by Rossman 1987: 45); Luzon, Mt. Maquiling, near Los Baños, in rust sori on leaves of *Bambusa* sp., ix.1913, [C.F. Baker, Fungi Malayana 92] (S, isotype of *Trichonectria bambusicola*, cf. Rossman l.c.)

Discussion. Rossman (1987: 43) erected the genus *Uredinophila* with *Ophionectria erinacea* Rehm as type species. The type is Baker no. 36, as stated by Rossman (1987: 45; however, the last paragraph under *Uredinophila erinacea* should start with "The type specimen of *Trichonectria bambusicola* is cited ..."). We examined an isotype in S, annotated by Rossman in 1973, and also original material of *T. bambusicola*, a synonym of *O. erinacea*. The ascomata studied by us contained numerous asci with long cylindrical ascospores which did not leave the asci in the squash mounts.

An anamorph was reported for *T. bambusicola* (as *Podonectria bambusicola*) by Pirozynski (1977: 603). See discussion under *Puttemansia miakei*!

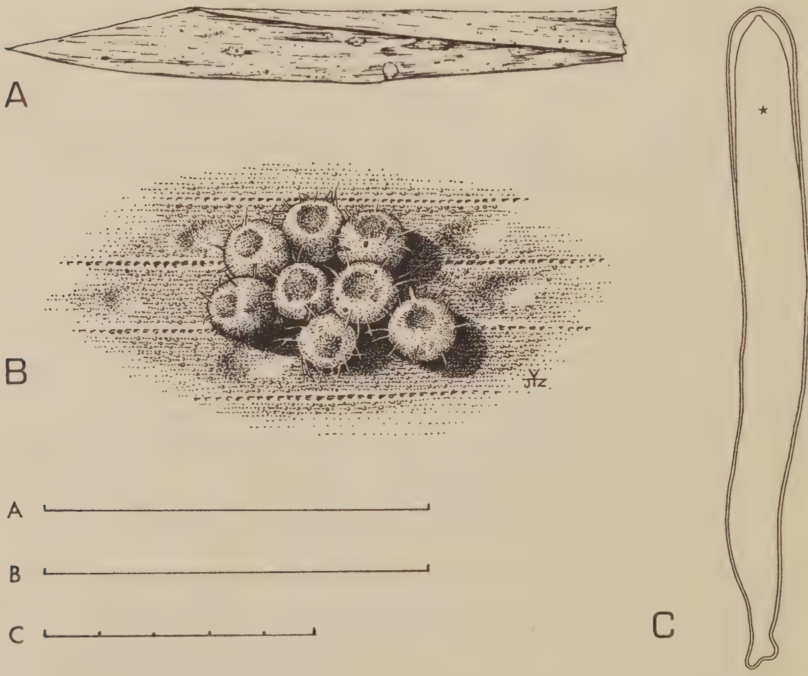

Fig. 10. *Uredinophila erinacea*. (A) Leaf with spots caused by rust sori parasitized by *U. erinacea*. (B) Ascomata. (C) Ascus with long cylindric ascospores (not shown). – Scales: (A) 60 mm. (B) 1 mm. (C) 50 µm. – Material: Baker no. 36 (S, isotype).

Acknowledgements

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MYCOTAXON

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CALVATIA TURNERI (ELLIS et EVERH.) DEMOULIN et M. LANGE, COMB. NOV., THE CORRECT NAME FOR *C. TATRENSIS* HOLLOS

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Abstract

Lycoperdon turneri Ellis et Everh. antedates with several years *Calvatia tatrensis* Hollós. Its well preserved type collection, which is here described, allows a clear identification. The necessary combination is introduced.

Résumé.

Lycoperdon turneri Ellis et Everh. est antérieur de plusieurs années à *Calvatia tatrensis* Hollós. Sa récolte type bien conservée, qui est ici décrite, permet une identification assurée. La combinaison nécessaire est introduite.

Calvatia, for which the names *C. cretacea* (Berk.) C. Lloyd, *C. arctica* Ferdinandsen et Winge and *C. tatrensis* Hollós are classically used, are frequent fungi in arctico-alpine vegetation. The harsh environment in which the fruitbodies slowly mature induces an important variability in the

Description of the type collection

The specimens we have located are two: one and a half at NY in the Ellis collection (holotype, fig. 1-4) , the other half being in K (isotype) . The largest specimen reaches 4 cm while the original description gives a diameter up to 6 cm; a larger specimen might thus be in another herbarium or have been lost. The best specimen is the one cut in two, being riper than the entire specimen. The cut specimen is pyriform, 4 cm in height, 2,5 cm in diameter, the other specimen is flattened, 2 cm in height, 3,5 cm in diameter. The subgleba is rather reduced with small locules and a rather pale brownish colour (not much flushed with lilacine). The exoperidium is made up of regular but very small (0,2 - 0,3 mm) spines made up of well developed spherocysts, up to 32 µm in diam., with a wall reaching 2 µm in thickness (in chloral hydrate). The spherocysts are often in chain and somewhat rectangular, for example 16 x 10 µm, wall 1,5 µm. The spines are well distinct from the thick pseudoparenchymatous layer. The endoperidium breaks up at the top of the fruitbodies through brittleness of the wall and multiplication of septa but not much swelling of hyphae (broadest hypha, 7,3 µm, wall 1,1 µm). At the gleba level, the hyphae are pale yellow and can be 5,0 µm in diam., with a wall of 0,9 µm. At subgleba level the hyphae are also very pale, but not septate and can also be 5.O µm in diam., but with walls up to 1,6 µm . At both levels the walls are cyanophilous, while they are more dextrinoid at the subgleba level. The capillitium is fragile, septate, and with small pores, not very abundant, punctiform or irregular in shape. The diameter reaches 6,4 µm and the wall 1,0 µm in thickness; the tips can be acuminate. The spores are verrucose, but not strongly (between B and C in V.D. notation), 5,1 - 5,5 - 5,8 µm in diameter,excluding the ornamentation, with 6 to 9 warts for 10 µm of circumference.

It should be noted that this collection is very similar to the type of *Calvatia tatrensis* var. *groenlandica* M. Lange, described by one of us in 1948. We do not consider the characters used to distinguish this variety are worth introducing a subdivision of *C. turneri*, either in the restricted sense of M. L. or the broad one of V. D.

glebal and especially peridial characters making the taxonomy of this group of species extremely difficult.

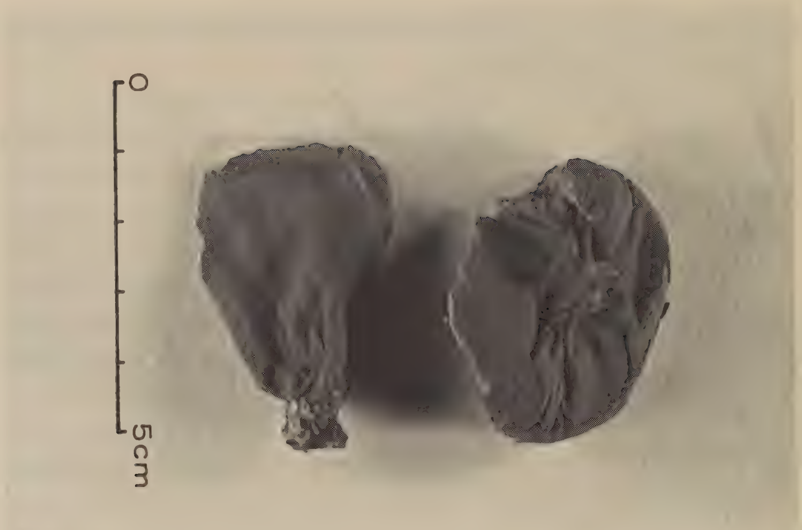
Although many authors have considered three taxa are involved (Lange, 1948; Eckblad, 1955), Miller et al. (1980) reduced them all to the synonymy of *C. cretacea.*

Recently both of us have independently reexamined the situation (Demoulin, 1989; Lange, 1990) with the common conclusion that the single taxon concept is untenable. One of us (M.L.) however believes a number of "small species" can be recognised, while the other (V.D.) feels two species only can be segregated in a clear cut way. Experience will tell which concept is the best, but the knowledge of this group is now developed enough for nomenclatural aspects to be considered. The major nomenclatural problem that needs to be discussed is the fact *Lycoperdon turneri* Ellis et Everh. is a *Calvatia* of the group under discussion and not a *Lycoperdon* as often assumed. At the time it was first announced this name probably antedated *Calvatia tatrensis* (Demoulin, 1979), no nomenclatural action was taken, because the group was considered in need of further study. Both of us now agree that the well preserved type collection originating from Labrador (NY, isotype K), is unequivocally what is called *C. tatrensis* and intend to use the name *C. turneri* either in a broad or restricted sense. We thus introduce the following combination :

Calvatia turneri (Ellis et Everh.) Demoulin et M. Lange, comb. nov.; basionym : *Lycoperdon turneri* Ellis et Everh., J. Mycol. I (7) : 87, 1885.

Synonym: *Calvatia tatrensis* Hollós, Gaster. Ung. 90, 1904.

(N. B. For reasons independent of our will, this paper will appear after the one by Lange (1990). In that paper, Lange considers the publication of the combination *Calvatia turneri* is to be found in the present paper. We thus consider that, despite enough data can be found in Lange (1990) for valid publication, the publication is not valid there under Art. 34.)



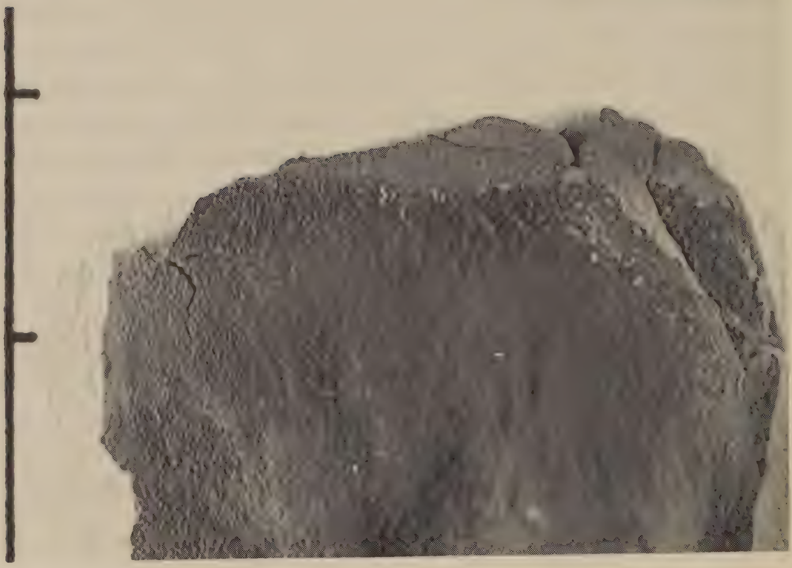
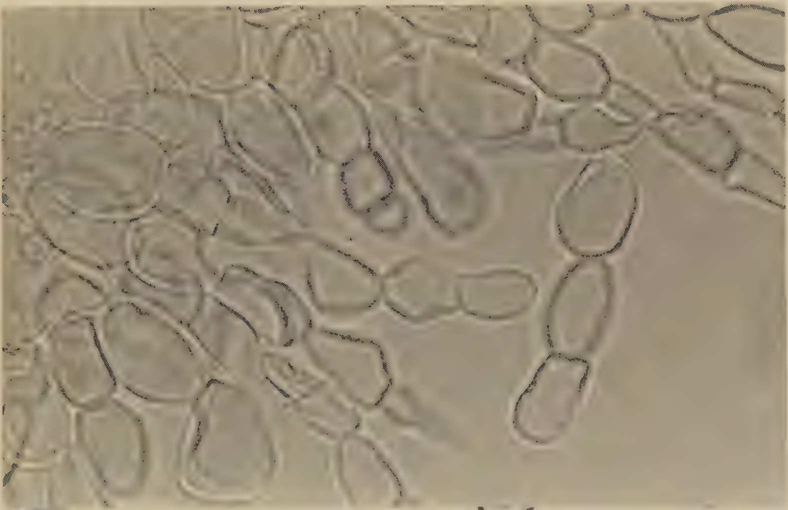


Fig. 1 (above). The type material of *Lycoperdon turneri* at NY.

Fig. 2 (below). The specimen cut in two in the type collection of *Lycoperdon turneri* at NY.



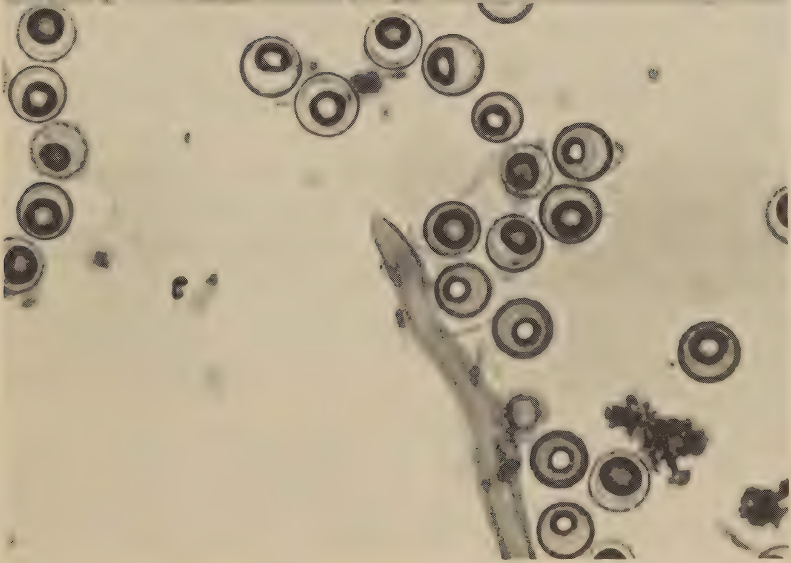


Fig. 3 (above). Spherocysts of the exoperidium of the specimen cut in two in the type collection of *Lycoperdon turneri* at NY, 750x (chloral hydrate).

Fig. 4 (below). Spores and capillitium of the entire specimen in the type collection of *Lycoperdon turneri* at NY, 1500x (lactophenol cotton blue).

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We are thankful to the curators of the Herbarium of the New-York Botanical Garden (NY) and Royal Botanic Gardens Kew (K) for the opportunities to study the type collection of *Lycoperdon turneri* and to Professor F.-E. Eckblad (University of Oslo) for critical reading of the manuscript.

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MYCOTAXON

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REDESCRIPTION OF PANDORA GLOEOSPORA (ZYGOMYCETES: ENTOMOPHTHORALES) FROM LYCORIELLA MALI (DIPTERA: SCIARIDAE)

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ABSTRACT

An entomopathogenic fungus isolated from Lycoriella mali (Fitch) (Diptera: Sciaridae) has been identified as Pandora gloeospora (Vuillemin) Humber. This is the first identification of P. gloeospora in North America and, apparently, the first collection since its original description. Pandora gloeospora is described in detail and compared with other species likely to infect L. mali.

INTRODUCTION

Lycoriella mali (Fitch) (Diptera: Sciaridae) is an economically important fly found in commercial cultivation of the mushroom Agaricus brunnescens Peck (= A. bisporus (Lange) Imbach). Larvae reduce yields by feeding extensively on compost, mushroom spawn and primordia. Adults are a nuisance to workers and transmit spores of fungi pathogenic to A. brunnescens, especially Verticillium fungicola (Preuss) Hassebrauk. Virus-infected spores of A. brunnescens, and other pests and pathogens such as pygmy mites and bacteria are probably carried by dispersing adults.

During pesticide resistance studies conducted in 1986-1987 (Keil, 1986) in commercial mushroom houses in Chester County, Pennsylvania, Pandora gloeospora (Vuillemin) Humber (= Erynia gloeospora (Vuillemin) Rem. & Henn.) was discovered to be a significant but sporadic entomopathogen of L. mali. Pandora gloeospora was originally described as an entomopathogen of an unspecified species of midge in France (Vuillemin, 1886). Subsequently, the species has been mentioned only in various taxonomic works concerning the Entomophthorales (Olive, 1906; MacLeod and Müller-Kögler, 1973; Remaudière and Hennebert, 1980; Humber, 1981, 1989; Ben-Ze'ev and Kenneth, 1982). Furia montana (Thaxter) Humber has also been reported as an entomopathogen of L. mali in California (Donald Betterly, personal communication) but neither this species nor a closely related species, Furia sciarae (Olive) Humber, has been found in Pennsylvania. It is probable that P. gloeospora or other closely related species have been entomopathogens on sciarid flies in mushroom houses for decades (Thomas, 1942) but their identification and study have been lacking. This paper presents a detailed description of P. gloeospora and comments regarding other species that may infect sciarid flies.

METHODS AND MATERIALS

Live adults of L. mali were collected by aspiration from several commercial mushroom houses in 1987-1988 in Chester County, PA. Dead, infected flies were collected by cutting cadavers from the stipe and cap of mushrooms. Conidia were collected by affixing infected flies to petri dish lids and allowing them to fall onto glass slides. Conidia were air dried before mounting in lactophenol/aniline blue or aceto-orcein for microscopic examination. Fifty conidia were measured from specimens collected periodically during the study. All other microscopic data were taken from fresh field collected specimens mounted in lactophenol/aniline blue or aceto-orcein. Measurements were made at 400X using bright-field optics. Development of mycosis in naturally infected adults was observed by placing CO_2-anesthetized flies into 100 x 15mm petri dishes with 1.5% water agar to prevent desiccation. Development was observed microscopically.

RESULTS AND DISCUSSION

PANDORA GLOEOSPORA (Vuillemin) Humber, 1989, Mycotaxon 34:453.

= Entomophthora gloeospora Vuillemin, 1886, Bull. Soc. Sci. Nat. Nancy, Sér. 2, 8(20):34.
= Zoophthora gloeospora (Vuillemin), Batko, 1964, Bull. Acad. Polon. Sci., Sér. Sci. Biol. 12:406.
= Erynia gloeospora (Vuillemin) Remaudière & Hennebert, 1980, Mycotaxon 11:302.

Dorsum of infected cadavers usually covered with a dense pale yellow to white hymenium of conidiophores (Fig. 1A). Hymenium was less dense in male flies. HYPHAL BODIES short, unbranched to sparsely branched (Fig. 1B), rapidly becoming hyphal and filling most of the body cavity. CONIDIOPHORES develop from multinucleate hyphae (Fig. 1C), becoming digitately branched, terminating in clavate uninucleate conidiogenous cells, 6.5 - 12.0 μm broad (Fig. 1D). PRIMARY CONIDIA pale yellow to cream in mass; uninucleate, bitunicate, ellipsoid, obovate or obpyriform (Fig. 2A), 13.0-21.0 μm in length x 8.0-12.0 μm in width (average 18.7 μm x 9.5 μm), equilateral to slightly inequilateral in profile; with one or more large lipid droplets; papillae short to slightly elongated with a blunt or rounded end, the wall sometimes roughened in outline and ending distinctly or gradually in the conidial wall; forcibly discharged. SECONDARY CONIDIA formed directly on short germ tubes, obovate to nearly subspherical, 10.5-15.0 μm in length x 8.0-10.6 μm in width (average 13.1 μm x 9.2 μm); papillae short and blunt; forcibly discharged. NUCLEI staining intensely in aceto-orcein, faintly or not at all in lactophenol/aniline blue, spherical to subspherical, 5-7 μm in diameter, nucleolus not visible. CYSTIDIA cylindrical to lageniform (Fig. 2B), 173-316 μm long, 12-25 μm broad at the sub-bulbous base, tapered above to 6-13 μm. RHIZOIDS 5-25 μm broad (average 13 μm), unbranched, non-septate, solitary (monohyphal) or in fasicles of 3-5;

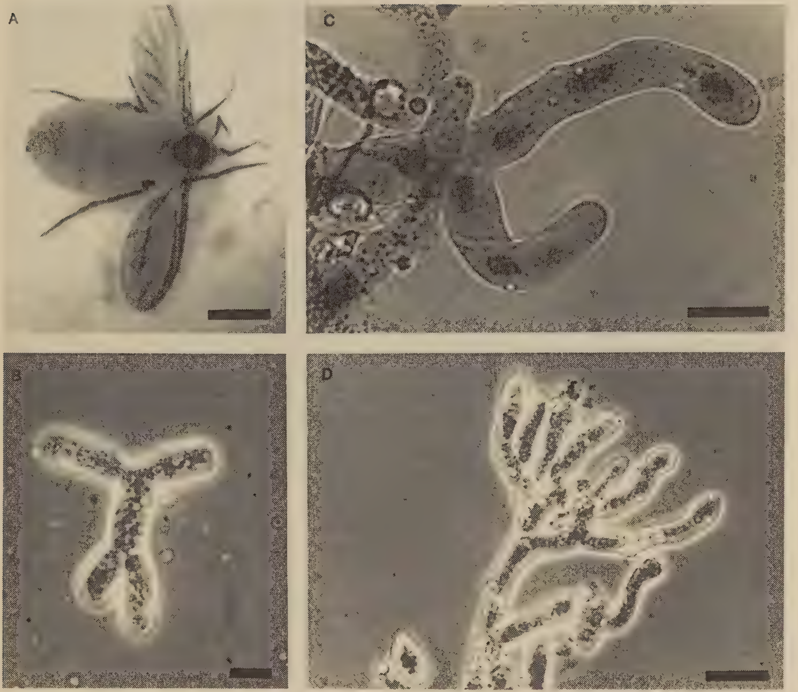

Figure 1. Lycoriella mali cadaver, hyphal body, and conidiophores. A. L. mali cadaver with Pandora gloeospora conidiophores protruding from membranous cuticle. Cadaver was attached to Agaricus brunnescens pileus by rhizoids not visible in photograph. Wings are in characteristic posture, bar = 1mm. B. Hyphal body isolated from hemolymph of infected adult. Stained with lactophenol/aniline blue, phase-contrast, bar = 10 μm. C. Developing multinucleate conidiophore dissected from infected adult. Stained with aceto-orcein, bar = 10 μm. D. Digitate conidiophore with terminal conidiogenous cells, dissected from infected adult. Stained with lactophenol/aniline blue, phase-contrast, bar = 20 μm.

terminal holdfast a lobed disc (Fig. 2C) or digitate (Fig. 2D). RESTING SPORES not observed.

Pandora gloeospora, as far as can be determined, is a rare species, and has not been collected and identified previously in North America. The description given here is similar to Vuillemin's (1886) description. The conidia from his material are somewhat larger (20 μm x 14 μm) but their shape and papillae are identical to our material. Vuillemin (1900) reported finding resting spores but none could be found in hundreds of cadavers examined during this study.

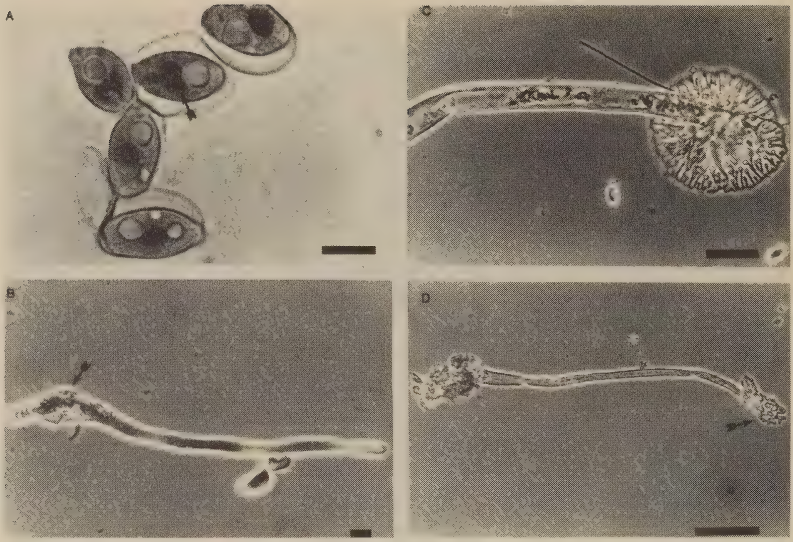

Figure 2. Conidia, cystidium and rhizoids of Pandora gloeospora from infected Lycoriella mali adult cadaver. A. Primary conidia with irregular nucleus (arrow), clear lipid droplets, the inner wall and outer wall. Stained with aceto-orcein, bar = 10 μm. B. Lageniform cystidium with sub-bulbous base (arrow). Stained with lactophenol/aniline blue, phase-contrast, bar = 10 μm. C. Detail of lobed-disc holdfast of a rhizoid. Stained with lactophenol/aniline blue, phase-contrast, bar = 30 μm. D. Complete rhizoid with digitate holdfast (arrow). Stained with lactophenol/aniline blue, phase-contrast, bar = 100 μm.

In vivo development of P. gloeospora on L. mali was variable. Typically, infected L. mali developed many rhizoids from poorly sclerotized cervical, coxal, plural and abdominal areas. Cystidia and conidiophores appeared within hours followed by sporulation. In other infected specimens of L. mali, rhizoids were not formed although cystidia and conidiophores developed normally. In low humidity, infected adults usually died in the typical spread-winged position (Fig. 1A) although no rhizoids, cystidia or conidiophores were produced. The entire body cavity of these flies was filled with mycelium and nearly all tissues digested.

Pandora gloeospora can readily be distinguished from Furia montana and F. sciarae, which occur on fungus gnats similar to L. mali (MacLeod and Müller-Kögler, 1973). Furia can be distinguished from Pandora by the lack of strongly differentiated discoid holdfasts on the rhizoids and/or cystidia which are as thick as the conidiophores (Humber, 1989). Furia montana apparently lacks rhizoids with terminal holdfasts and the conidia are distinctly fusoid and often curved (Thaxter, 1888; Gustafsson, 1965). Furia sciarae also apparently lacks rhizoids with a distinct terminal holdfast, and although cystidia were not reported by Olive (1906), it is possible that they were overlooked if not thicker than the conidiophores, or variable in expression on the host. In P. gloeospora, the pattern of rhizoid, cystidia and conidial development is variable depending on the environment, time of infection, sex of the fly and larval diet, but the morphology of the fungal structures remains constant when expressed.

ACKNOWLEDGEMENTS

We thank the mushroom growers who allowed us access to their farms to collect L. mali. Dr. Richard A. Humber, USDA-ARS (Ithaca, NY), confirmed our identification of Pandora gloeospora and reviewed the manuscript. The fungus is deposited as Erynia gloeospora, 10787-1, NRRL 18430, at the Patent Culture Collection, USDA, ARS, Peoria, Illinois. Voucher specimens of infected L. mali cadavers are deposited in the University of Delaware, Dept. of Entomology Insect Museum. This research was supported, in part, by Ecogen, Inc. Langehorne, PA, and the Delaware Research Partnership. Published as Contribution No. 602 of the Department of Entomology and Applied Ecology and Miscellaneous Paper No. 1279 of the Delaware Agricultural Experiment Station, University of Delaware, Newark, Delaware.

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NEW OR NOTEWORTHY DISCOMYCETES. 1. SOME STROMATIC FUNGI ON ALNUS OR BETULA.

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Abstract

Five inoperculate discomycetes on leaves of *Alnus* and *Betula* [Betulaceae] are treated: ***Rutstroemia conformata***, ***Hymenoscyphus rufescens***, ***Pseudociboria umbrina***, ***Pycnopeziza pachyderma***, and ***P. sympodialis.***

Introduction

Quite a few stromatic fungi have been recorded on *Alnus* and *Betula*. Groves & Elliott (1961) provided a key to 11 species on *Alnus*, of which the majority occur on the floral organs and fruits of their hosts.

In this outline, five species of the family Sclerotiniaceae or very similar forms, which occur on the leaves of *Alnus* spp. and *Betula* spp., are treated: ***Rutstroemia conformata***, ***Hymenoscyphus rufescens*** comb. nov., ***Pseudociboria umbrina***, ***Pycnopeziza pachyderma*** and ***P. sympodialis***.

1. *Rutstroemia conformata* (Karst.) Nannf. in Lundell & Nannf., F. exs. suec. no. 1174. 1942. - *Peziza conformata* Karst., Not. Sällsk. F. Fl. Fenn. Förh. 10: 149. 1869. - *Helotium conformatum* (Karst.) Karst., Not. Sällsk. F. Fl. Fenn. Förh. 11: 236. 1870. - *Ombrophila conformata* (Karst.) Boud., Hist. class. discom. d'Eur. 92. 1907. - *Ciboria conformata* (Karst.) Svr., Ceská Mykol. 36: 152. 1982.

= *Phialea violascens* Rehm in Sacc., Syll. fung. 14: 767. 1899. - *Ciboria violascens* (Rehm) Jaap, Verh. Bot. Vereins Brandenburg 52: 5. 1910. - *Ombrophila umbonata* Karst. f. *violascens* Rehm, Ber. Bayer. Bot. Ges. 15: 248. 1915.

[= *Sclerotinia umbonata* (Karst.)Karst. var. *alni* Rehm in sched. nom. nud.]

?= *Sclerotinia nervisequa* Schröt., Cohn's Krypt.-Fl. Schles. 3(2): 65. 1893 (fide Lundell & Nannfeldt 1942, Dennis 1956). - *Rutstroemia nervisequa* (Schröt.) White, Lloydia 4: 223. 1941.

Specimens examined:

FINLAND. Mustiala, Åbo, on leaves of *Alnus* sp., May 1868 (H F. fenn. exs. no. 738 **isotype**).

SWEDEN. Upland. Bondkyrka , Fyris at Ultuna, on last year's leaves of *A. glutinosa* (L.) Gaertn., Aug 10 1939 S. Lundell (UPS F. exs. suec. no. 1174); Bohuslän. Løkholmen in Dynekil, on last year's leaves of *A. glutinosa*, May 25 1985 E. Johannesen (O).

NORWAY. Oslo. Maridalen, Snippen, on leaves of *A. incana* (L.) Moench, Jun 7 1989 A. Holst Jensen (O); same locality, on leaves of *Betula pubescens* Ehrh., Jun 7 1989 A. Holst Jensen (O).
GERMANY. Brandenburg, Spandauer Forst., on leaves of *Alnus glutinosa*, Jun 1885 P. Sydow (S ex herb. Sydow, Mycoth. march. no. 764, labelled *?Ombrophila ramella* Karst.; Berlin. Wannsee, on leaves of *Alnus rugosa* (DuRoi) Spreng., Jun 1894 P. Sydow (S Mycoth. march. no. 4157, labelled *Ciboria pachyderma* Rehm.; Brandenburg, Oranienburg, on leaves of *A. glutinosa*, May 21 1905 H. Sydow.(S ex herb. Rehm, labelled *62 Sclerotinia umbonata* (Karst.) var. *alni* Rehm 20/9 (1)905); Berlin, Finkenkrug, on leaves of *Alnus glutinosa*, Jul 1897 P. Sydow (S Mycoth. march. no. 4761 **isotype** of *Phialea violascens*).

Apothecia one to several from blackened, stromatized patches on host leaves; disc light cinnamon to umber brown, shallow cupulate to flat, 0.5-3 mm in diam, stipe concolorous, 0.5-7 mm long, 0,3 -0.8 mm wide. **Ectal excipulum** 20-60 µm wide, of light brown globose to angular cells, 5-30 µm in diam., 3-7 rows thick, outermost cells smaller, giving rise to scattered 1-few-celled tomentum hyphae ca 2-3 µm broad, to 30-50 µm long. **Medullary excipulum** 30-70 µm wide, of hyaline, densely packed textura intricata, hyphae 5-7 µm broad. **Subhymenium** a compact zone, 10-30 µm wide, of densely interwoven, short-celled hyphae; entire excipulum and subhymenium without gelatinous matrix. **Asci** cylindrical, 8-spored, 65-95 x 6-8 µm, with an undivided, abrupt base, pore channel walls faintly bluing in J+ without pretreatment in 2% KOH, after pretreatment strongly J+. **Ascospores** uniseriate, ellipsoid, equilateral with slightly pointed ends, hyaline, without conspicuous internal guttules, 6.5-9.8 x 4.2-5.2 µm. **Paraphyses** simple or branched from below, straight, light brown, septate, ca 1.5 µm broad, slightly inflated to 2.2-3.5 µm at tips.

Notes. The small, subsessile to short-stipitate apothecia arise from blackened areas on leaf laminas, ribs and petioles of fallen leaves, usually of *Alnus* spp. *Alnus glutinosa* is a main host of the species in Europe (cf. Dennis 1956, Matheis 1985), *Betula pubescens* and ? *Populus tremula* L. (Schröter 1893) representing the more exceptional host species of the fungus.
Based on microanatomy and growth habit the species is accepted in *Rutstroemia* sensu lato. The type specimen of *Phialea violascens* corresponds fully with the material, including Karsten's type of *Peziza conformata*; consequently *Phialea violascens* Rehm is considered to be a later synonym of *P. conformata* Karst.
Lundell & Nannfeldt (1942) and Dennis (1956) included *Sclerotinia nervisequa* Schröt., originally described from leaves of *Alnus glutinosa* and *Populus tremula* (Schröter 1893), in their concept of *Rutstroemia conformata.* I have not examined type material of *S. nervisequa*.

2. *Hymenoscyphus rufescens* (Kanouse) T. Schum. **comb. nov.**
[Basionym: *Ciboria rufescens* Kanouse, Mycologia 33: 463. 1941.] - *Ciboriella rufescens* (Kanouse) Seaver, North Amer. Cup-fungi (Inop.) 107. 1951.- *Lanzia rufescens* (Kanouse) Dumont, Mycologia 67: 570. 1975.

Specimens examined:
U.S.A. Washington. Olympic Peninsula, Hoh River, on *Alnus* leaves, Jun 30 1939 A. H. Smith 14710 (MICH **holotype**); Washington. Lake Quinault, on *Acer* leaves, May

17 1939 A. H. Smith 13509 (MICH **paratype**).

Notes. This species seems to be rather frequent on leaves of *Alnus* spp. in northwestern North America (Kanouse 1941, Dumont 1975, Carpenter 1981). Dumont (1975) provided a description of the apothecial microanatomy of the species. Since he observed a substratal stroma on the leaf remains in the type collection, he referred *Ciboria rufescens* Kanouse to the genus *Lanzia* of the Sclerotiniaceae.

My reexamination of the type specimens revealed some apricot orange to brick red, cartilaginous, stipitate apothecia, arising from leaf laminas of withered *Alnus* leaves. On the leaf surfaces, there are several blackened patches of a substratal stroma. Microscopically, the outermost excipulum consists of a short-celled textura prismatica, approaching a textura angularis toward the flanks of the receptacle, and there is no gelatinous matrix present in the ectal excipulum. A close examination of the well preserved holotype specimen under the stereomicroscope shows apothecia which arise from non-stromatized areas of the leaves, and not from the substratal stroma. The leaves are apparently attacked by another stromatic fungus as well in addition to *C. rufescens*, e.g. ? *Pseudociboria umbrina* Kanouse (see below). Since there are no culture data of a stroma being an integral part of the life history of *C. rufescens*, Seaver (1951) and Korf (1973) were probably correct in treating this fungus, and its accommodating genus *Ciboriella* Seaver (1951), in the Leotiaceae rather than in the Sclerotiniaceae. The gross and micro-anatomy of the apothecia very well fit a *Hymenoscyphus* species, and a formal transfer to this genus is therefore proposed. Korf (1973) apparently also came to the same conclusion when placing the monotypic *Ciboriella* into synonymy with *Hymenoscyphus*, a disposition concurred here.

3. *Pseudociboria umbrina* Kanouse, Mycologia 36: 460. 1944. - *Helotium umbrinum* (Kanouse) Seaver, North Amer. Cup-fungi (Inop.) 147. 1951.

Specimen examined:

U.S.A. Washington, Lake Crescent Olympic Forest, on leaves of *Alnus* sp., May 19 1937 A. H. Smith 13579, labelled *Ciboria rufescens* Kanouse (MICH **lectotype** here designated, - ex paratype of *C.rufescens*).

Apothecia short-stipitate, dark brown, arising from blackened, stromatized areas of the leaf surface, disc 0.3-1 mm broad, gradually tapering to a stalk 0.5-1.5 mm high, by 0.5 mm wide. **Ectal excipulum** of longitudinally oriented hyphae (textura prismatica), 30-60 µm wide, individual hyphae partly short- celled and inflated, from 4-12 µm broad, cell walls light brown and partly encrusted with pigments, outermost covering hyphae narrow and running parallel to the receptacular surface, giving rise to scattered hair-like processes; at margin the hyphal tips are clavately enlarged and heavily encrusted with pigments. **Medullary excipulum** 30-90 µm wide, of a dense textura intricata to textura prismatica gradually passing into the ectal excipulum; the excipular tissues without gelatinous matrix, not bluing in Melzer's reagent. **Subhymenium** of densely packed, short-celled hyphae, 5-6 µm broad. **Hymenium** composed of asci and two distinct types of paraphyses. **Asci** subcylindrical, 8-spored, uniseriate to partly biseriate, 55-90 x 6-7 µm. **Ascospores** ellipsoid, with slightly pointed ends, hyaline, one-celled, with two more or less equal internal polar guttules, 6-9 x 3.3-4.2 µm. Ordinary **paraphyses** filiform, ca. 1 µm wide, straight, septate, partly branched from the middle of its length, at tips inflated to 1.5-2 µm; inbetween there are numerous dark brown, broad and cylindrical **non-septate paraphyses**, 3.5-4.5 µm broad, 'filled with dark brown coloring matter, broken up into short sections resembling beads, along the entire length of the filaments' (Kanouse 1944).

Notes. Because of the 'lack of a stromatic condition' and the presence of two types of paraphyses, Kanouse (1944) erected a distinct genus, i.e. *Pseudociboria* Kanouse, for the fungus. Dumont (1974) reexamined the holotype collection (MICH - A. H. Smith 18933), and judged from the observation of a substratal stroma, and his interpretation of possibly dark-coloured ascospores in the Cotton blue-mounted preparation studied by him, he concluded that *Pseudociboria* was a taxonomic synonym of *Lambertella* emend Dumont (1971); the species *P. umbrina* was tentatively placed into synonymy with *Lambertella chromoflava* (Rick) Dumont. As pointed out by Dumont (1974), because of the fragmentary condition and paucity of apothecia of the type specimen, there were some features described in the protologue, that could not be reconfirmed. Through the kindness of Dr. Robert Shaffer (MICH) I have been informed that the holotype of *P. umbrina* and the only specimen hitherto recorded of that species has been exhausted. Obviously, I was more than surprised, when re-examining the A. H. Smith collection no. 13579 (paratype of *Ciboria rufescens*), in finding in the packet two small apothecia undoubtedly referable to *P. umbrina*. This collection has previously been annotated by Dumont (1243 - November 30, 1972) as 'paratype of *C. rufescens* mixed with an undetermined species'. I was unable to find any remnants of *C. rufescens* in this collection, however, the apothecia of the 'other species' have made the basis for a redescription here of *Pseudociboria umbrina*. This newly discovered specimen is taken from the same locality as that of the above cited holotype specimen; it has been collected on the same substrate, i.e. leaves of *Alnus* sp., by the same collector (A. H. Smith) two years earlier. Consequently, the material represents a topotype specimen, and is considered to be a suitable lectotype of *P. umbrina*, as designated here.

Judged from the microscopic reexamination of the well preserved apothecia, *P. umbrina* is not easily accommodated in any existing genus, as was pointed out originally also by Kanouse (1944). The apothecia, which arise from indefinite stromatized patches of host tissues, a feature overlooked by Kanouse (1944), the dimorphism of the paraphyses, the non-septate hyaline ascospores, in combination with an ectal excipulum of textura prismatica, represent a unique set of characteristics which in my opinion necessitates a reassessment of the genus *Pseudociboria* Kanouse. *Peziza sejournei* Boud. (= *Ciboria sejournei* (Boud.) Rehm) is a species which should be compared with *Pseudociboria umbrina*. This taxon was accommodated in the genus *Pycnopeziza* by Whetzel and White (1940). Judged from the original description of *Peziza (Phialea) sejournei* of Boudier's (1881, 1910), I can see no good characteristics that would indicate a close relationship to *Pycnopeziza*. On the other hand, the brown, sessile apothecia and the presence of heavily melanized paraphyses of the hymenium in my opinion should justify a comparison with *Pseudociboria* (see also Boudier 1910, pl. 484).

4. *Pycnopeziza pachyderma* (Rehm) Whetz. & White, Mycologia 32: 617. 1940.
- *Ciboria pachyderma* Rehm in Rabenh. Krypt. Fl. 1(3): 758. 1893.
  = *Pycnopeziza quisquiliaris* (Ell. & Ev.) White & Whetz., Mycologia 30: 192.

1938. - *Cyathicula quisquiliaris* Ell. & Ev., Proc. Acad. Sci. Philadelphia 1893: 451. '1894'

Pycnidial anamorph:
Acarosporium quisquiliaris White & Whetz. ex Sutton, Coelomycetes (Kew): 34. 1980. [- *Acarosporium quisquiliaris* White & Whetz., Mycologia 30: 192. 1940 nom. inval.]

Specimens examined:
GERMANY. Berlin. Jungfernheide, on leaves of *Quercus* sp., primo Jun 1886 P. Sydow (UPS Mycoth. march. no 1269 **isotype**).
U.S.A. Iowa. Iowa city, 'on overwintered leaves of *Quercus* sp., *Ranunculus septentrionalis* Poir. etc.', May 4 1927 G. W. Martin (CUP 15608 authentic, determ. White & Whetzel).

Notes. The species has been adequately described by White & Whetzel (1938), and a description needs not be repeated here.

The distinctive features of ***Pycnopeziza*** White & Whetzel (1938) are:
sessile to short-stipitate brownish apothecia, which are at first pyriform and closed, then expanding and opening in a more or less stellate manner; the hymenium in the mature ascocarp being somewhat retracted, resulting in a protruding and stellately split apothecial margin; apothecia arise from a definite stroma with a differentiated rind and a medulla; the stipe, and lower parts of the receptacle being covered by a layer of polygonal, thick-walled, dark brownish, 'carbonaceous' cells being continuous with and not much differentiated from stromatic rind cells proper, this outermost layer being easily separable from the underlying excipular tissues; and conidia borne in pycnidia which produce dichotomously branched chains of 15-20 cylindrical arthroconidia from the conidiophore to the apex of any branch (= *Acarosporium* Bubak & Vleugel), the conidia with (= *A. sympodiale*) or without (= *A. quisquiliaris*) lateral whip-like appendages.

The type specimen of *P. pachyderma* includes both apothecia and the pycnidial anamorph. *P. pachyderma* typically occurs on leaves of *Quercus* spp. Whetzel and White (1940) recorded *Alnus* as an exceptional host, including in their material a specimen in Sydow's Mycotheca marchica (No. 4157, on leaves of *Alnus rugosa*). I have re-eamined this specimen, which is here referred to *Rutstroemia conformata* (see this taxon above). Whetzel & White (1940) also referred the specimens in Sydow's Mycotheca marchica No. 3480 (on *Salix* leaves), No. 3777 (on *Prunus* leaves) and No. 3955 (on *Spiraea* leaves) to *P. pachyderma*. A re-examination of these exsiccate specimens made me conclude that the specimens are conspecific, however, representing a species in the neighbourhood of *Velutarina* Korf, and not *P. pachyderma*. Consequently, based on extant evidence, *P. pachyderma* is retained as a species occurring on *Quercus* spp.
P. pachyderma has been recorded from Germany (Rehm 1893, as *Ciboria pachyderma*), Czechoslovakia (Velenovsky 1934, as *C. pachyderma*) and England (Clark 1980, Dennis 1981) in Europe, and from Iowa, New York and West Virginia in North America (Ellis & Everhart 1894, as *Cyathicula quisquiliaris*, White & Whetzel 1938, as *Pycnopeziza quisquiliaris*, Whetzel & White 1940).

5. ***Pycnopeziza sympodialis*** White & Whetz. ex Sutton, Coelomycetes (Kew): 34. 1980. [- *Pycnopeziza sympodialis* White & Whetz. (ut '(Bub. & Vleug.) White & Whetz.), Mycologia 30: 190. 1938; descr. angl. tantum]

Pycnidial anamorph:
Acarosporium sympodiale Bub. & Vleug., Ber. Deutsch. Bot. Ges. 29: 385. 1911.
- *Pycnopeziza sympodialis* (Bub. & Vleug.) White & Whetz., Mycologia 30: 190. 1938.

Specimens examined:
U.S.A. New York. Malloryville. Bank Pitcher Plant Bog, on male inflorescenses of *Acer rubrum* L., April 18 1937 White, Butler & Sproston (CUP 25859 **holotype**, UPS duplicate).
SWEDEN. Vestergötland. Skallsjö. Floda, leaves of *Betula pubescens*, May 16 1937 T. Nathorst-Windahl (UPS - Nannf. & Holm, F. exs. suec. no. 3310).

Notes. An adequate description was provided by White & Whetzel (1938). In North America *P. sympodialis* occurs on overwintered buds and inflorescenses of its hosts on the ground; on buds and staminate inflorescenses of *Acer rubrum*, catkins of *Alnus rugosa*, buds of *Populus candicans* Ait., and buds and catkins of *P. tremuloides* Michx. (cf. White & Whetzel 1938). The above cited Swedish material, which represents the first record of the teleomorph outside North America, includes both apothecia and pycnidia occurring side by side on the *Betula* leaves. The pycnidial anamorph, *Acarosporium sympodiale* Bubak & Vleugel, was originally described from Sweden, also on leaves of *Betula pubescens* (= *B. odorata* Bechst.) (Bubak 1911).

Acknowledgements

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MYCOTAXON

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SPORES OF ALEURODISCUS AMORPHUS

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Aleurodiscus amorphus (Fr.) Schroet. (Corticiaceae) is common in North America, North and Central Europe and Asia on dry branches of living Abies spp. In Fennoscandia this fungus often occurs also on Picea abies (Andersson, 1976; Eriksson & Ryvarden, 1973).

Lately A. amorphus was collected in Estonia for the first time in Rapla District at Märjamaa on dry branches of two trees of Picea abies (distance ca 100 m). Spore prints were taken from these two collections and spores (per 30) were measured in 2% KOH solution at the magnification x700.

The spore size measured by us is somewhat larger than those published in literature:

Eriksson & Ryvarden (1973): about 20 x 15 μm;
Lemke (1964): 20-26(-29) x 16-20(-23) μm;
Boidin et al. (1985): 24-27.8-30-(37) x 19-21.6-25 μm;
Our data (spore print): 24-29-32 x 21-26-30 μm.

It is unknown, whether the published data are obtained from spore prints or basidiomata. For the comparison of spore print data with those obtained from the basidiomata of herbarium samples, we measured six A. amorphus collections from the herbarium TAA which had spore prints taken. Spore length (L), width (W), length/width quotient (Q) and volume (transformed into equivalent spore diameter D) were compared (Table 1).

Table 1

MEAN SPORE SIZE AND D VALUES (n = 6)

	L	W	Q	D
Basidiomata	25.57	21.17	1.21	22.54
Spore print	29.43	25.01	1.18	26.40

Spore size and volume (but not Q values) are different in spore samples, taken from basidiomata, and in spore prints obtained from the same basidiomata. The difference is statistically significant at 0.001 level (Student's t-test and ANOVAR). The difference in Q values is insignificant ($\alpha = 0.34; 0.35$).

Table 2

SPORES OF ALEURODISCUS AMORPHUS

Herb. no.	Locality		Host	L	W	Q	Volume	D
TAA 126057	E	Estonia	P. abies	26.36	21.83	1.21	6577.4	23.25
TAA 126057	E*	Estonia	P. abies	30.44	26.58	1.14	11260.4	27.81
TAA 126058	E	Estonia	P. abies	26.27	22.63	1.16	7044.2	23.78
TAA 126058	E*	Estonia	P. abies	27.75	25.14	1.10	9183.2	25.98
TAA 126330	E	Perm	A. sibirica	24.52	19.53	1.26	4896.9	21.07
TAA 126330	E*	Perm	A. sibirica	28.42	24.17	1.18	8693.2	25.51
TAA 126338	E	Perm	A. sibirica	25.10	21.52	1.17	6086.4	22.65
TAA 126338	E*	Perm	A. sibirica	32.68	25.11	1.30	10788.8	27.41
TAA 104267	E	Perm	A. sibirica	25.51	20.57	1.24	5651.7	22.10
TAA 104267	E*	Perm	A. sibirica	28.76	25.14	1.14	9517.4	26.29
TAA 126371	E	Perm	A. sibirica	23.70	18.55	1.28	4270.1	20.13
TUR 28278	E	FRG	A. alba	26.07	20.28	1.28	5614.1	22.05
TUR 28276	E	Yugoslavia	A. alba	26.09	21.00	1.24	6024.4	22.57
LY 2875	E	France	A. alba	27.68	21.31	1.30	6581.6	23.25
TAA 59705	F	Primorye	P. ajanensis	24.76	20.74	1.19	5576.6	22.00
TAA 106197	F	Primorye	A. holophylla	25.97	21.27	1.22	6151.9	22.73
TAA 126160	F	Primorye	A. nephrolepis	26.07	22.17	1.18	6709.2	23.40
TAA 102636	F	Primorye	A. nephrolepis	26.43	21.80	1.21	6576.7	23.24
TAA 52745	F	Primorye	A. nephrolepis	26.77	21.68	1.23	6588.2	23.26
TAA 102560	F	Sachalin	A. sachalinensis	26.54	22.22	1.19	6861.0	23.58
TAA 151418	N	Tennessee	A. fraseri	25.63	20.96	1.22	5895.6	22.41
TAA 151418	N*	Tennessee	A. fraseri	28.53	23.94	1.19	8561.5	25.38
CFMR 05776	N	Idaho	A. lasiocarpa	26.13	20.45	1.28	5721.7	22.19
DAVFP 2993	N	Canada	A. grandis	24.95	18.07	1.38	4265.7	20.12
DAOM100430	N	Canada	Pinus strobus	24.98	19.41	1.29	4927.7	21.11
DAOM100328	N	Canada	A. balsamea	25.02	20.20	1.24	5345.5	21.69
FH s.n.	N	Canada	A. balsamea	26.13	20.35	1.28	5665.9	22.12
DAOM 9402	N	Canada	A. grandis	26.56	19.65	1.35	5369.7	21.73
DAOM 73670	N	Canada	A. amabilis	28.76	20.79	1.38	6508.8	23.16

E - Europe, F - Soviet Union Far East, N - North America

* - spores from a spore print

To clarify possible differences in spore size caused by geographical distribution, spore measurements (from basidiomata) of 23 collections from different regions were compared. As a result differences in spore size and D values appeared statistically insignificant.

90 %-expected tolerance limits of the means of all specimens and spore prints studied by us (calculated as described in Parmasto & Parmasto, 1987: 111-112) are as follows:

L = 23.35-29.93 μm; W = 18.02-25.22 μm; Q = 1.12-1.36; D = 19.80-26.54 μm.

Data on the material studied are presented in Table 2. Herbarium names are abbreviated according to Lanjouw & Stafleu (1964).

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Alpine and subalpine fungi of the Cascade Mountains. I. *Hymenogaster glacialis* sp. nov.

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ABSTRACT

A new *Hymenogaster* species is described from a fungal community in the recently exposed forefront of Lyman glacier in the North Cascades, Washington.

INTRODUCTION

The Cascade mountains run north-south from southern British Columbia to northern California, forming a barrier to storms blowing east from the Pacific Ocean. The range creates a sharp west to east moisture gradient, with heavy precipitation on the west slopes grading in a pronounced rain show to steppe and tundra on the farthest eastern slopes. Heavy snowfall near the crest has produced heavy glaciation in the past. Glaciers are presently active on higher peaks in the south and even relatively low summits to the north, especially in northern Washington state. Glaciation has produced deeply dissected topography, resulting in strikingly different habitats over distances of less than a hundred meters. Ancient and recent volcanism has further imprinted the Cascade landscape with diversity, ranging from high volcanic peaks to tephra deposits of varying texture and depth.

This is the first report of our studies of fungi of the Cascades. One area that we have intensively studied is the forefront of the receding Lyman glacier. Fig. 4. This subalpine area (elev. ca. 1900 m.) is characterized by well-developed moraines, fluting, and outwash. The newest plant colonization is on moraines exposed from the receding ice for 40-60 years; these infant communities include nonmycorrhizal *Carex*, *Juncus*, and *Saxifraga* spp. and ectomycorrhizal *Salix spp.* and *Abies lasiocarpa* (Hook.) Nutt. Older moraines support increasingly diverse communities, with *Salix* spp. as low, scattered shrub dominants.

METHODS

Methods of collection and study of macroscopical features are essentially those of Smith (Smith and Zeller, **1966**). Glacier forefronts are very stony, however, we have discovered many sporocarps, even of agarics, by looking under stones. That was how the undescribed *Hymenogaster* was discovered, microscopical features are essentialy those used by Fogel (**1985**). Color names are given as the ISCC-NBS color number (Kelly and Judd, **1955**).

DESCRIPTION

Hymenogaster glacialis Cazares & Trappe, *sp. nov.*
Figs. 2-4.

***BASIDIOMATA** 3-6 mm in diam, subglobosa, coacta, sordide alba.* GLEBA *brunnea, loculis irregularibus, usque ad 1 mm in diam.* ***COLUMELLA** absens.* ***PERIDIUM** evanescens, 30-150 µm crassum; epicute 20-100 µm crassa, hyphis hyalinis, cellulis elongatis vel subglobosis usque ad 20 µm in diam; subcute 30-60 µm crassa, hyphis hyalinis, intertextis, usque ad 5 µm in diam.* ***TRAMA** 20-80 µm crassa, hyphis confertim subparallelis vel intertextis, usque ad 5 µm in diam.* ***SUBHYMENIUM** cellulis hyalinis, subglobosis, usque ad 5-20 µm in diam.* ***BASIDIA** 20-25 x 5-9 µm, cylindrica, hyalina, 4-spora.* ***SPORAE** 15-18 (-19) x (-11) 12-15 (-16) µm, ornamentum includens, L/W= 1.18-1.25 late ellipsoideae vel ellipsoideae, ornamento verrucoso-rugoso usque ad 2 µm alto; apex papillatus; basis truncata, 1-2 µm crassa; in KOH singulatim brunneae, aggregatae obscure brunneae.* ***HOLOTYPUS:** Trappe # 10418 (OSC).*

BASIDIOMATA 3-6 mm in diam, subglobose, surface felty, sordid white, unchanging upon drying. **GLEBA** deep brown (ISCC-NBS 56), locules irregularly shaped and up to 1 mm in diam, randomly arranged. **COLUMELLA** absent, but some young sporocarps have cottony sterile tissue at the base. **RHIZOMORPHS** absent. **ODOR** not distinctive, taste not determined.

PERIDIUM evanescent, 30-150 µm thick, two-layered: epicutis 20-100 µm thick, of hyaline, thin-walled hyphae up to 5 µm at septa,with elongated to inflated cells up to 20 µm in diam; subcutis 30-60 µm thick, of hyaline, thin-walled, interwoven hyphae up to 5 µm in diam; clamp connections absent.

TRAMA 20-80 µm wide, of compact, thin-walled, subparallel to interwoven, hyaline, nongelatinous hyphae up to 5 µm in diam; clamp connections absent. **SUBHYMENIUM** of 2-3 rows of hyaline, thin-walled, compactly arranged, subglobose cells, 5-20 µm in diam. **BASIDIA** 20-25 x 5-9 µm, cylindrical, hyaline, thin-walled, 4-spored, clamp connections absent at base.

SPORES 15-18 (-19) x (-11) 12-15 (-16) µm including ornamentation, but not beak or pedicel, L/W=1.18-1.25; broadly ellipsoid to ellipsoid; the ornamentation warty-wrinkled and up to 2 µm tall; apex papillate, 1-3 x 1-3 µm, paler than spore proper, not ornamented; base truncate, 1-2 µm wide. In KOH, brown singly, dark brown in mass; in Melzer's reagent, golden brown singly, orange brown to reddish brown in mass.

ETYMOLOGY: Latin, “of glacial”.

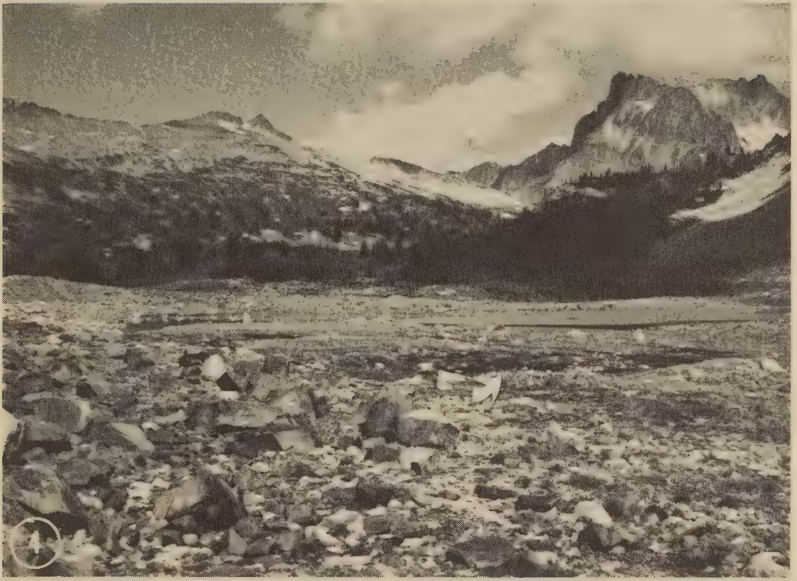
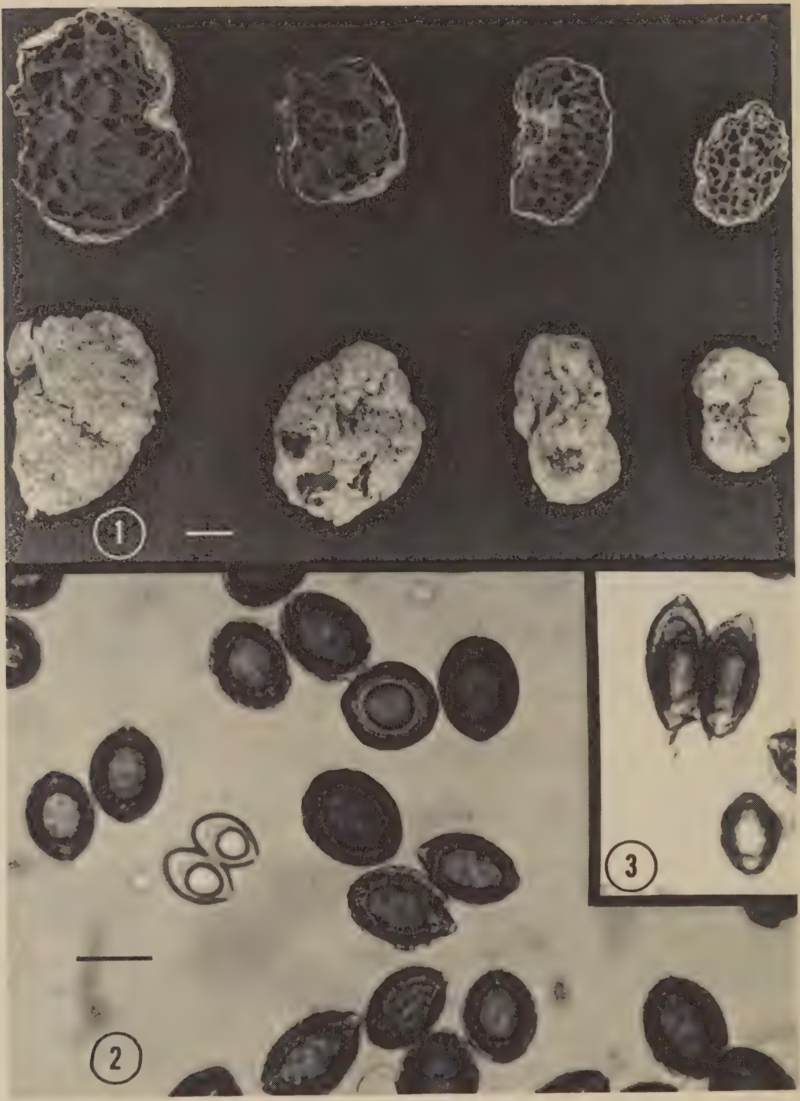


Fig. 1. Lyman glacier forefront. Arrow marks dwarf willow clumps.

HOLOTYPE: Washington, Chelan County, Lyman Glacier forefront, 2 September 1988, elevation 1900 m, hypogeous under stones in wet area among dwarf *Salix* roots in raw moraine, leg. Efren Cazares and Jim Trappe # 10418 (OSC).

NOTES: Spore dimensions of this species clearly relates it to *H. gilkeyae* Zeller & Dodge (Zeller & Dodge, **1934**), which has spores 15-22 x 10-11 µm. The small size of the basidiomata, the evanescent, thin peridium and the relatively large locules of the gleba distinguish *H. glacialis* from the other *Hymenogaster*.spp.



Figs. 2-4. ***Hymenogaster glacialis.*** Fig. 2. Dried sporocarps in cross-section, photo courtesy of Dr. D. Luoma. Bar= 1 mm. Fig. 3. Basidiospores. Bar= 10 µm. Fig.4. Basidiospores attached to basidia.

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EMBELLISIA AND RELATED TELEOMORPHS

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SUMMARY

Five species are added to *Embellisia* E. Simmons as novel or as transfers from *Alternaria* Nees, and the teleomorphs of two of these are described in *Allewia* E. Simmons, gen. nov. (Pleosporaceae): *E. novae-zelandiae* E. Simmons & C. F. Hill, sp. nov., from *Leptinella dioica*; *E. leptinellae* E. Simmons & C. F. Hill, sp. nov., from *L. dioica*; *E. dennisii* (M. B. Ellis) E. Simmons, comb. nov., from *Senecio jacobaea*; *E. proteae* E. Simmons, sp. nov., from *Protea* sp., with *Allewia proteae* E. Simmons, sp. nov., produced in culture; and *E. eureka* (E. Simmons) E. Simmons, comb. nov., from *Medicago rugosa*, with *Allewia eureka* (E. Simmons) E. Simmons, comb. nov., produced in culture.

****

The definition of *Embellisia* E. Simmons (1971) and the descriptions of thirteen species for the genus (Simmons 1971, 1983) serve as bases for identifying a few of the 15-20 congeneric isolates shared with me since that time and for presenting several of the others as species novel to the genus.

Distinguishing *Embellisia* from *Alternaria* Nees, in particular, still presents problems, as the overall patterns of growth in culture, sporulation, and conidium color and septation are very similar.

Conidiophore structure in *Embellisia* is similar to that of *Alternaria* (and several other genera) -- distinctive erect or ascending, cylindrical lateral hyphal outgrowths from vegetative mycelium; conidiophore elongation involving a series of one or more geniculate conidiogenous extensions, each lateral to a previously formed coniogenous pore. Conidiogeny is apical from the conidiophore tip, possibly tretic; in any case evidence of the original site of connection between a conidium and its conidiophore is a narrow channel, perhaps an invaginated connective, visible within the rounded basal wall of the conidium. Conidium septation is transverse in both genera and additionally longitudinal in at least a few conidia of practically every species known.

Pigmented septa of *Alternaria* conidia usually become concolorous with the mature outer wall; the septum wall layers, notably primary ones but also the secondary thickenings, appear to be continuous with similar layers in the outer wall of the conidium. Septa of *Embellisia* conidia initially are very thin and pale and appear to be continuous with the outer wall; but the circumference of the strikingly thickened secondary septum layers appears to terminate abruptly as a flat, pigmented ring at the hyaline inner limit of the outer wall. This conspicuous aspect of *Embellisia* conidial septa is our most useful clue to the dissimilarity between *Embellisia* and *Alternaria*.

1. Two New Species on *Leptinella* in New Zealand

Two distinct species of *Embellisia* are represented by isolates from *Leptinella dioica* Hook. f. (Compositae) and *L. maniototo* (Petrie) Lloyd & C. Webb in New Zealand. Neither one is identical with any *Embellisia* species described previously.

Embellisia novae-zelandiae E. Simmons & C. F. Hill, sp.nov.
Fig. 1

Ex cultura in agaro V-8 post dies novem descripta. Chlamydosporae non visae. Conidiophora simplicia, plerumque 5-6-geniculata in locis conidiogenis. Sporulatio primaria copiosa; sporulatio secundaria infrequens in conidiophoris secundariis locis conidiogenis 1-4. Conidia initio ovoidea vel cylindrica, deinde ovoidea vel ellipsoidea, lateraliter symmetrica, dilute fulva, septis fuscatis transversalibus 3-5(-8) et longitudinalibus aut obliquis 0-4, 18-28(-37) x 7-10µm, apparenter levia. Habitatio typi Leptinella dioica, Papakura, New Zealand. Typus: partes ex EGS 39-099 (ex isol. C. F. Hill 4252(a), lect. July, 1989) desiccatae et in BPI *(holotypus) et pro isotypus saltem in* IMI, NY *et* PDD *conservandae.*

Embellisia novae-zelandiae grows well on PCA, Hay decoction, and 20% V-8 agars, sporulating copiously on simple multigeniculate conidiophores that arise for the most part directly from the substrate but also, as a culture ages to 2-3 weeks, appearing to a major extent as lateral branches of conspicuous procumbent vegetative hyphae; conspicuous non-sporulating aerial mycelium is

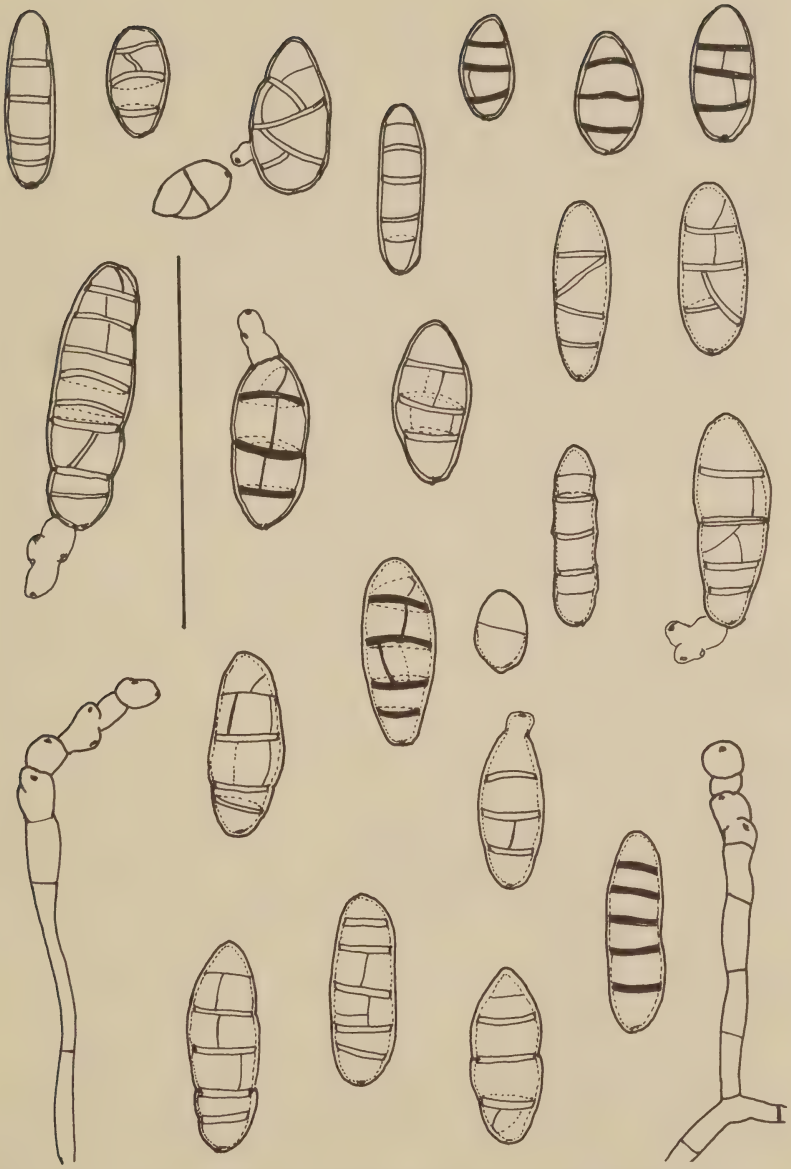

Fig. 1. Embellisia novae-zelandiae; typical conidia and patterns of primary and secondary conidiophore proliferation, ex EGS 39-099. Magn.: bar = 50µm.

lacking in the type isolate. The sorts of swollen or chlamydosporic hyphal elements known for several species of *Embellisia* have not been seen in 2-3-week-old cultures of *E. novae-zelandiae.*

Conidiophores usually are unbranched; they bear solitary conidia at each of 5-6 closely geniculate sites at the apex of the conidiophores (increasing to 20-25 after 2-3 weeks). Most of the primary conidia remain solitary, but a few in any sample can be found to have produced a secondary conidiophore with 1-4 conidiogenous sites from the apical conidial cell or lateral to the basal pore. Ovoid juvenile conidia tend to retain an oval shape as they enlarge to about 20-22 x 8-10μm with 3-4 transverse and 1-2 longitudinal or oblique septa; cylindric juvenile conidia tend to become ellipsoid as they elongate and broaden to about 28-37 x 10μm with 5-8 transverse and 3-4 longitudinal or oblique septa. Mature conidium color in transmitted light is a dilute golden tan crossed by deeper shades of the same color in the broad bands of septum circumference that abut the outer wall of the conidium. Conidium walls are essentially smooth.

Representative isolates include EGS 39-093 (C. F. Hill 4102B, ex leaf of *Leptinella maniototo*, coll. June 1989, Auckland, New Zealand); EGS 39-099, source of type (C. F. Hill 4252(a), ex *L. dioica*, coll. July 1989, Papakura, N.Z.; EGS 39-100 (C. F. Hill 4252(b), ex *L. dioica*, coll. July 1989, Papakura, N.Z.).

When compared with the thirteen *Embellisia* species treated earlier (Simmons 1983), *E. novae-zelandiae* has keying characters near *E. planifunda* (whose conidia are smaller and have fewer septa), *E. allii* (conidia larger and usually lack longitudinal septa), and *E. telluster* (conidia commonly laterally asymmetric and usually lack longitudinal septa). At low magnifications (ca. 60X), conidiophores of *E. novae-zelandiae* are seen to bear tight terminal clusters of 20-40 conidia.

Embellisia leptinellae E. Simmons & C. F. Hill, sp. nov.
Fig. 2

Ex cultura in agaro V-8 post dies novem descripta. Chlamydosporae abundae, submersae, in catenis ramosis et coacervatis. Conidiophora simplicia vel ramosa, plerumque 4-6-geniculata in locis conidiogenis primariis. Sporulatio primaria abunda; sporulatio secundari abunda in conidiophoris secundariis locis conidiogenis 4-5. Conidia initio ellipsoidea vel cylindrica, dein ovoidea vel longe ellipsoidea, lateraliter symmetrica, dilute fulva, septis fuscatis

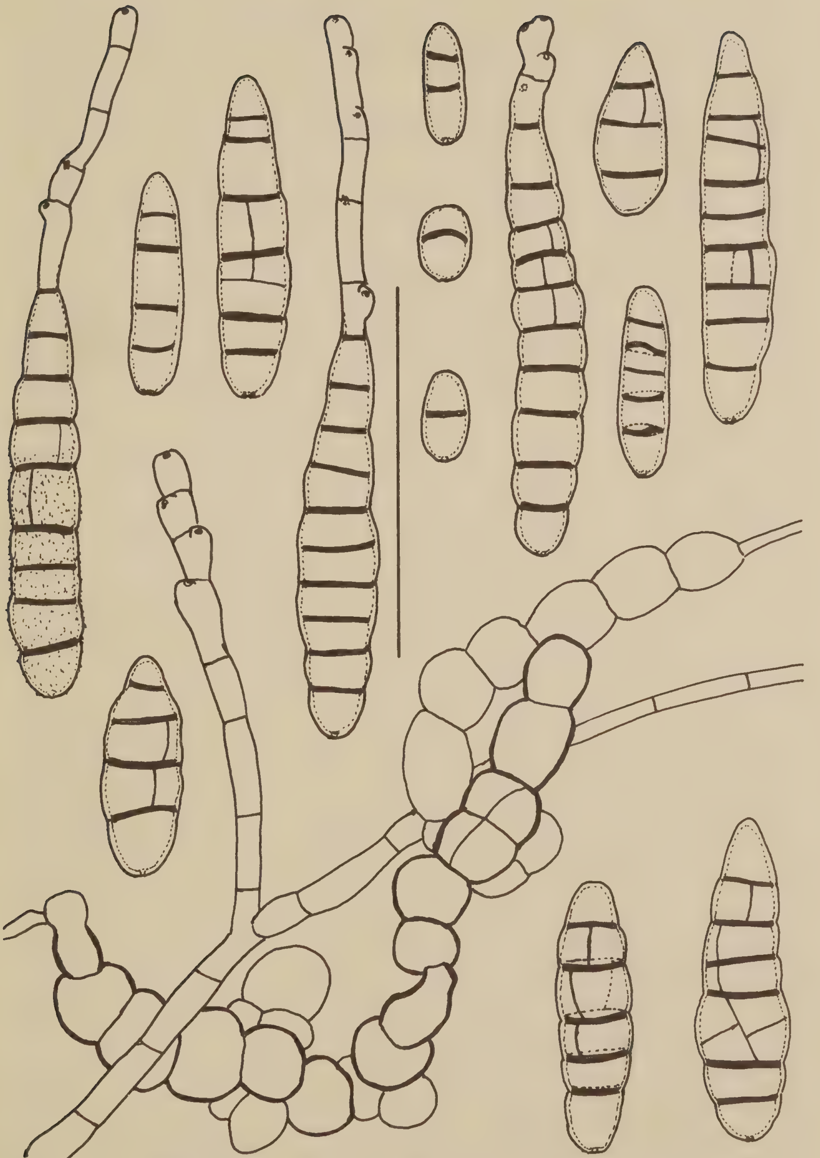

Fig. 2. Embellisia leptinellae; typical conidia, patterns of primary and secondary conidiophore proliferation, and branching chain of thick-walled hyphal cells, ex EGS 39-101. Magn.: bar = 50µm.

transversalibus (3-4-)7-10 et longitudinalibus 1-4, 30-65 x 10-13μm, levia vel minute verruculosa. Habitatio typi Leptinella dioica, Papakura, New Zealand. Typus: partes ex EGS 39-101 (ex isol. C. F. Hill 4252(c), lect. July 1989) desiccatae et in BPI *(holotypus) et pro isotypus saltem in* IMI, NY *et* PDD *conservandae.*

Embellisia leptinellae grows well on PCA, Hay decoction, and 20% V-8 agars, sporulating abundantly on simple or sometimes branched conidiophores that arise directly from the substrate or as lateral branches of conspicuous procumbent aerial hyphae; non-sporulating aerial mycelium forms a lanose layer over sporulating colonies on Hay agar, but it typically does not occur in colonies on PCA or V-8 agar. Chains of adjoining cells in submerged mycelium frequently enlarge, become variously septate, proliferate in branches and clumps, darken, and become thick-walled.

Conidiophores may remain simple with an apical clump of conidia, or they may branch and produce additional conidia near the tip of each branch. Primary conidiophores (those arising from vegetative hyphae) usually produce 5-8 successive, geniculate, conidiogenous cells as they lengthen; one or more of the associated 5-8 primary conidia may germinate in place and generate a secondary conidiophore with 3-5 successive, geniculate conidiogenous sites. The maximum conidium production of a primary conidiophore and its 2-3 associated secondary conidiophores after 2-3 weeks is about 25. Ellipsoid juvenile conidia usually become ovoid as they enlarge to about 25-45 x 10-13μm with 3-7 transverse and 1-4 longitudinal septa; cylindric juveniles tend to become narrowly ellipsoid as they elongate and broaden to about 45-65 x 9-10μm with 7-10 transverse and 1-3 longitudinal septa. Mature conidium color in transmitted light is a dilute golden tan crossed by the deeper shades of the same color marking the broad bands of secondary septum wall circumference. Conidium surfaces are smooth or become minutely verruculose.

Representative isolates include EGS 39-085 & 39-086 (ex IMI 330203 & 330204, both originally isolated from *Leptinella* sp. in New Zealand); 39-101, source of type (C. F. Hill 4252(c), ex *Leptinella dioica*, coll. July 1989, Papakura, N. Z.); 39-102 (C. F. Hill 4252(d), ex *L. dioica*, coll. July 1989, Papakura, N. Z.).

Embellisia leptinellae, with its long, narrow conidia and strong tendency to produce abundantly conidiogenous secondary conidiophores, is unlike any other species of the genus except the following *E. dennisii*.

2. *Embellisia dennisii* on *Senecio*

Embellisia dennisii (M. B. Ellis) E. Simmons, comb. nov.
Fig. 3

Basionym: *Alternaria dennisii* M. B. Ellis, CMI Mycol. Papers 125, p. 27. 1971. Type: IMI 151744 (EGS 30-024), on leaves of *Senecio jacobaea* L., Isle of Man, coll. R. W. G. Dennis, 20 Sept. 1970. Representative culture ex type: EGS 30-121 (ex IMI 151744).

Embellisia dennisii grows and sporulates well on PCA and V-8 agars (radially ca. 1 cm. in two weeks), though more slowly than do *E. leptinellae* and *E. novae-zelandiae*. More non-sporulating aerial mycelium develops in culture colonies of *E. dennisii* than has been seen in cultures of the other two species.

Conidiophores predominantly arise directly from the substrate surface; they are mostly simple with apical geniculate extensions or they may become branched. Primary conidiophores produce only 1-4 conidiogenous sites; these sites usually are well separated rather than tightly clustered as, for example, in *E. leptinellae*. Under culture conditions, most of the primary conidia produce secondary conidia from scarcely differentiated apical cells or from long 3-4-geniculate secondary conidiophores. A third generation of conidia may arise apically or laterally from secondary conidia. The resultant sporulation cluster is a somewhat loose arborescent arrangement of about 10-20 conidia. Primary conidia typically become long cylindrical or narrowly obclavate, 50-100 x 7-8µm, with 8-13 transverse and 0-1(-2) longitudinal septa; second generation conidia are cylindrical to subovoid, 30-40 x 6-8µm, with 5-8 transverse and 0-1 longitudinal septa; third generation conidia are ellipsoid or short ovoid, about 20-25 x 8-9µm, with 3-4 transverse and 0-2 longitudinal septa. Most conidia are essentially smooth walled. Mature conidium color in transmitted light is a dilute yellowish tan crossed by deeper shades of the same color in the relatively broad bands of secondary septum wall circumference.

The long, narrow, infrequently longiseptate primary conidia of *E. dennisii*, the abundance of strikingly long secondary conidiophores, and the arborescent sporulation pattern distinguish the species from the somewhat similar *E. leptinellae* with its broader, usually longiseptate conidia clustered at the tips of conidiophore branches.

Only the type specimen and an isolate derived from it, as cited above, are known at present for *E. dennisii*.

3. *Embellisia* Species with Teleomorphs.

Isolates of an undescribed typical species of *Embellisia* that readily produce simple ascomata with bitunicate asci in culture have required re-examination of the fungus described earlier (Simmons 1986) as *Alternaria eureka* E. Simmons and its teleomorph *Lewia eureka* E. Simmons.

Embellisia proteae E. Simmons, sp. nov. Fig.4

Ex cultura in agaro V-8 post dies novem descripta. Chlamydosporae non visae. Conidiophora pauca, sparsa, simplicia vel ramosa, plerumque 5-10-geniculata in locis conidiogenis primariis. Sporulatio primaria et secundaria haud abunda. Conidia initio ovoidea vel ellipsoidea, dein ovoidea, longe ellipsoidea vel obovoidea, lateraliter symmetrica, dilute fulva, septis fuscatis transversalibus 2-6(-7) et longitudinalibus 0-3, 18-32 x 7-12µm, levia. Habitatio typi Protea sp., Australia. Typus: partes ex EGS 39-031 (ex IMI 320290) desiccatae et in BPI *(holotypus) et pro isotypus saltem in* IMI *et* NY *conservandae. Teleomorphosis: Allewia proteae* E. Simmons, sp. nov.

Embellisia proteae grows poorly on PCA, Hay, and V-8 agars. Surface colonies comprise sparse patches of arachnoid to lanose aerial mycelium, simple or branched conidiophores arising directly from the agar substrate or from aerial mycelium, scanty sporulation, and few (on PCA) to abundant (on V-8) simple pleosporaceous ascomata.

Conidiophores usually remain simple but sometimes branch, each producing an apical cluster of 5-8 primary conidia or a series of as many as 10 spaced at geniculations in the upper half of the conidiophore. Secondary conidia on very short apical conidiophores are rare. Conidia initially are ovoid or ellipsoid, becoming ovoid, long ellipsoid or obovoid, laterally symmetrical, 18-32 x 7-12µm, with 2-6(-7) transverse and 0-3 longitudinal septa. Mature conidium color in transmitted light is a dilute golden tan crossed by the deeper shades of the septum walls.

Representative isolates include EGS 39-031, source of the type (ex IMI 320290, originally isolated from *Protea* sp., Australia) and two others from the same host and country, EGS 39-032 and 39-035 (ex IMI 320291 and 321017, respectively).

Embellisia proteae shares too few key characters (Simmons 1983) with other species of the genus to permit identification with any of them. In addition, it readily

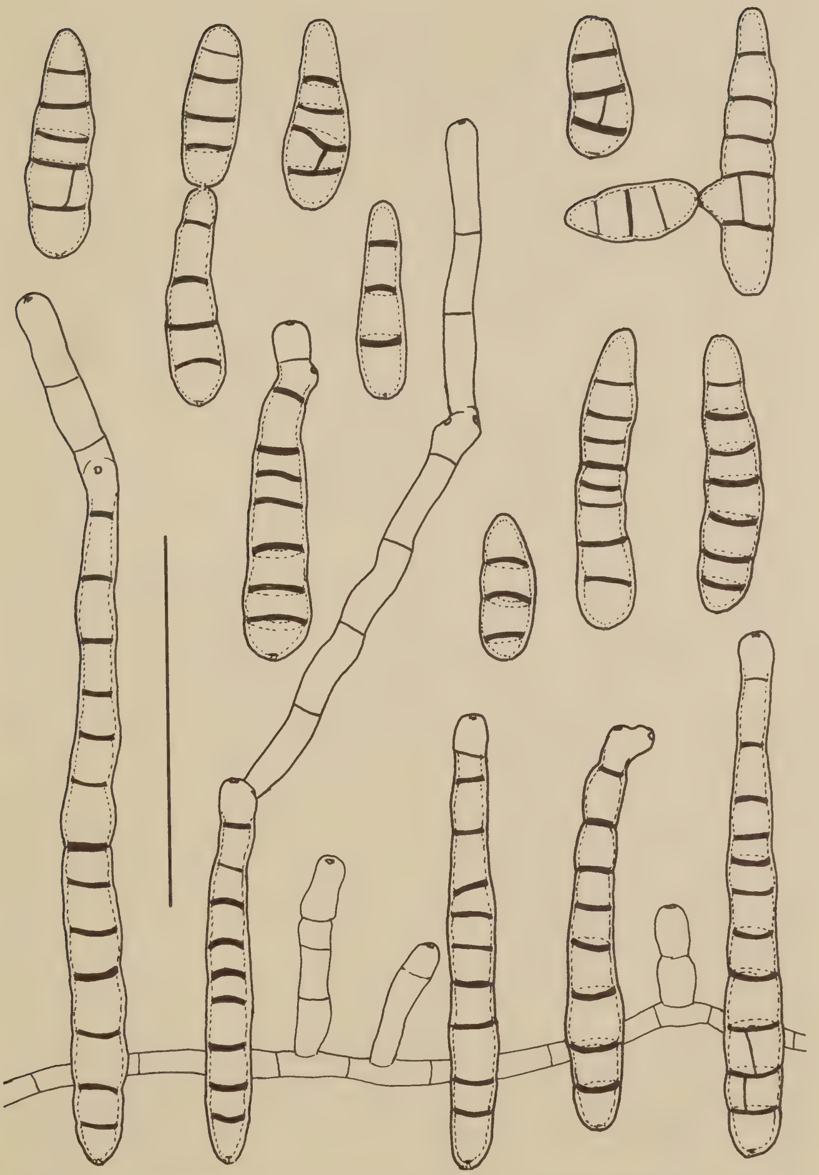

Fig. 3. Embellisia dennisii; typical conidia and patterns of primary and secondary conidiophore proliferation, ex EGS 30-024. Magn.: bar = 50μm.

produces a teleomorph in culture, described below as a new species, *Allewia proteae*, in a new genus of simple Pleosporaceae that is defined to encompass as well another *Embellisia* and its teleomorph, published earlier as *Alternaria eureka* E. Simmons and *Lewia eureka* E. Simmons (Simmons 1986).

Embellisia eureka (E. Simmons) E. Simmons, comb. nov.

Basionym: *Alternaria eureka* E. Simmons, Mycotaxon 25: 306. 1986. Holotype: BPI, EGS 36-103 (reisol. conid. EGS ex cult. IMI 273162, from seed of *Medicago rugosa* Desv. in Lam., Paragosa, Australia); l.c., Fig. 39. Teleomorph: *Allewia eureka* (E. Simmons) E. Simmons, comb. nov.

The 1-3 major transverse septa of *E. eureka* conidia are comparatively thick and dark and fit the pattern of disjunct secondary septum morphology detailed for *Embellisia* in the introductory comments above.

4. Teleomorphs of *Embellisia* Species.

The teleomorphs of *E. proteae* and *E. eureka* are similar to those described as species of *Lewia* Barr & Simmons (Simmons 1986). However, holomorph *Lewia* is defined to some extent (but not entirely) and recognizable among similar pleosporaceous genera by the presence or generation of its anamorphs, species of *Alternaria*. Since I hold the view that distinguishable anamorph genera have at least as useful holomorph systematizing characters as do their related teleomorphs, I have no problem with establishing a genus name for teleomorphs connected with *Embellisia* species, leaving the relational integrity of *Lewia-Alternaria* intact. I regret only that over-attention to the characters and segregation of *Lewia* (Simmons 1986) allowed me to stumble in including *Embellisia eureka* (as *Alternaria eureka*) in that place.

ALLEWIA E. Simmons, gen. nov. Pleosporaceae

Ascostromata sphaeroidea vel ovoidea, atra, setosa, parietibus tenuibus, apice rostellata. Asci subcylindrici vel subellipsoidei, recti vel curvati, bitunicati, vulgo 8-spori. Ascosporae juventute subellipsoideae, inaequilaterae; maturitate subclavatae vel ellipsoideae, ad septa parum constrictae, septis transversis, septis longitudinalibus in segmentis transversalibus, et cellulis terminalibus septatis aut eseptatis. Anamorphoses species Embellisia E. Simmons. Typus: A. proteae E. Simmons, sp. nov.

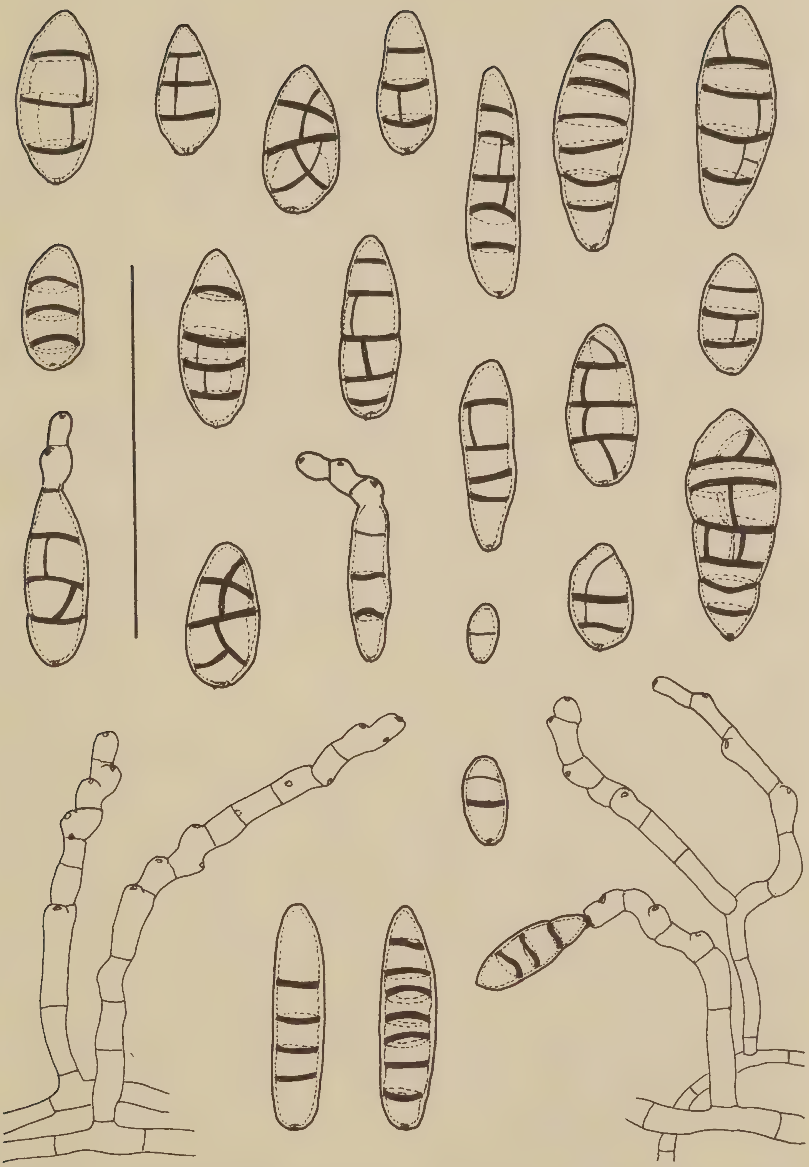

Fig. 4. Embellisia proteae; typical conidia and patterns of primary and (rare) secondary conidiophore proliferation, ex EGS 39-031. Magn.: bar = 50µm.

Ascostromata are sphaeroid to ovoid, thin-walled, dark, apically papillate by the time asci begin to mature, conspicuously setose. Asci are subcylindric to subellipsoid, straight or somewhat inequilateral, bitunicate, usually 8-spored. Juvenile ascospores are subellipsoid and slightly inequilateral; mature ascospores are subclavate to ellipsoid, with transverse septa, discontinuous series of longitudinal septa through major central spore segments, and with or lacking a longitudinal septum in terminal cells. Anamorphs are species of *Embellisia* E. Simmons.

Allewia is known to me only on the basis of *Embellisia* isolates that produce ascomata under conditions of axenic culture. It seems unlikely, given our present descriptive base for simple pleosporaceous ascomata, that teleomorphic *Lewia* and *Allewia* can be distinguished from each other generically in field material. The point cannot be settled, of course, before typical *Embellisia* isolates are derived from ascospores of a suitable wild collection, of which none is known to me at present. *Lewia* and *Allewia* are distinguishable from each other on the basis of their anamorph components, which is sufficient grounds for maintaining both genus names and which, in fact, may serve as one more clue to an understanding of the relationships and lines of diversity that underlie taxonomic concepts of the Pleosporaceae.

Allewia proteae E. Simmons, sp. nov. Fig. 5

Ex culturis in agaro V-8 descripta. Ascomata subglobosa vel ovoidea, 125-200 x 100-150µm, atra, parietibus tenuibus, setosa, apice rostellata. Asci clavati vel ellipsoidei, recti vel curvati, 8-spori, 125-150 x 20-30µm. Ascosporae juventute subclavatae vel ellipsoideae, parum inaequilaterae; maturitate ellipsoideae vel inaequilateraliter ellipsoideae, medio constrictae, dilute aureobruneolae, septis transversis 7(-9), septis longitudinalibus 1 in segmentis mediis transversalibus et in segmentis terminalibus 0-1, 24-27(-32) x 7-9(-10)µm. Typus: partes ex EGS 39-031 (reisol. conid. ex cult. IMI 320290, ex Protea sp., Australia) desiccata et in BPI *(holotypus) et pro isotypis saltem in* IMI *et* NY *conservandae. Anamorphosis: Embellisia proteae E. Simmons.*

Allewia proteae grows poorly on PCA, Hay, and V-8 agars. Colonies of sparse patches of arachnoid to lanose mycelium produce scattered conidiophores and few (on PCA) to abundant (on V-8) ascomata within 2-3 weeks.

Ascomata are subglobose to ovoid, 125-200 x 100-150µm,

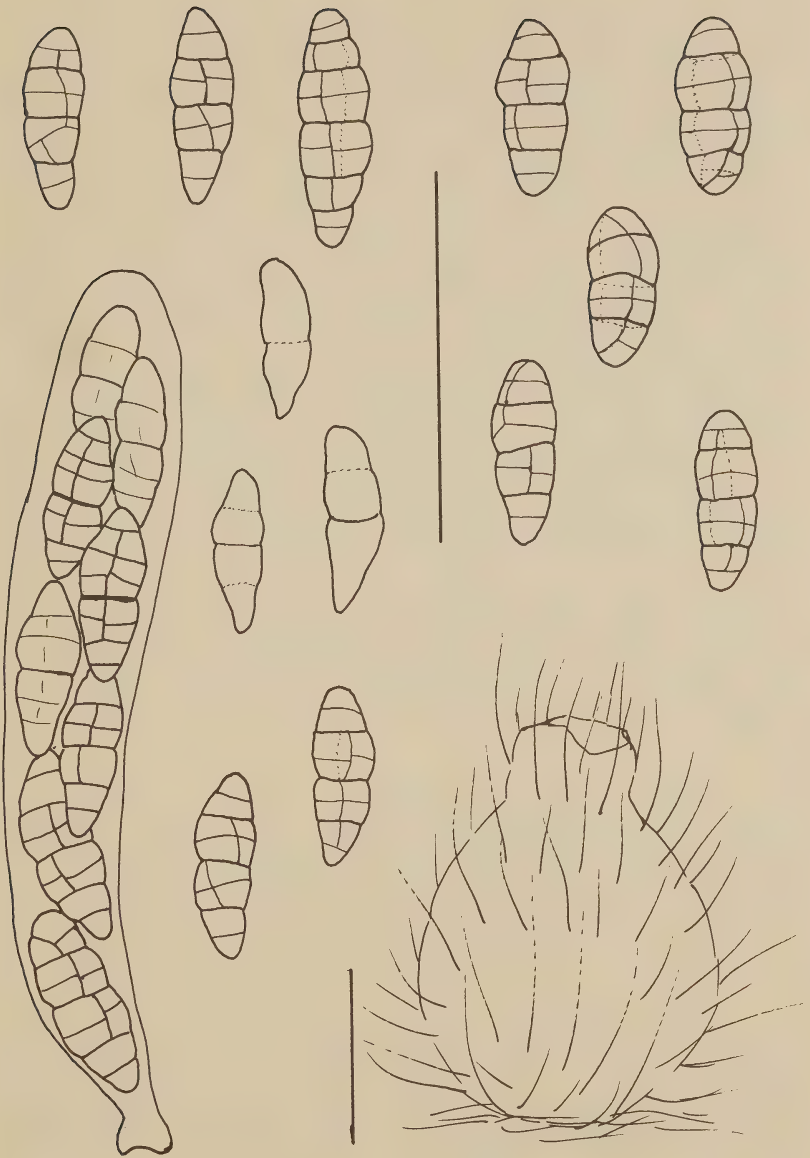

Fig. 5. Allewia proteae; typical ascus, ascospores showing progressive septation complexity, and ascoma, ex EGS 39-031. Magn.: ascospore bar = 50μm, ascoma bar = 100μm.

thin walled, dark and setose; they generate an apical beak ca. 70-90 x 50µm. Asci are clavate to ellipsoid, straight or curved, 8-spored (asci sometimes lack a full complement of mature ascospores), 125-150 x 20-30µm. Juvenile ascospores are subclavate to ellipsoid, often decidedly inequilateral; mature ascospores are narrowly to broadly ellipsoid, sometimes slightly inequilateral, decidedly constricted at the median transverse septum and often somewhat constricted at additional two major transverse septa; usually have 7 but may have as many as 9 transverse septa, one discontinuous series of longitudinal septa in all central divisions, and occasionally one longitudinal or Y-septum in terminal cells; and are 24-27(-32) x 7-9(-10)µm, dilute green-gold tan.

Representative isolates include EGS 39-031, source of the type (ex IMI 320290, isol. from *Protea* sp., Australia), and two others from the same host and country, EGS 39-032 and 39-035 (ex IMI 320291 and 321017, respectively).

Mature ascospores of *A. proteae* usually have narrower ends, more strongly constricting median septa, and 2-4 more transverse septa than are seen in *A. eureka*.

Allewia eureka (E. Simmons) E. Simmons, comb. nov.

Basionym: *Lewia eureka* E. Simmons, Mycotaxon 25: 304. 1986. Holotype: BPI, EGS 36-103 (reisol. conid. ex cult. IMI 273162, from seed of *Medicago rugosa*, Australia); l.c., Fig. 39. Anamorph: *Embellisia eureka* (E. Simmons) E. Simmons.

Remarks in the basionym description of *Allewia eureka* (l.c., 1986) need to be revised on the basis of measurements of asci produced more recently in cultures grown in parallel with those of *A. proteae*. Specifically, asci of *A. eureka* can mature at a size about equal to that of many asci of *A. proteae*, viz., ca. 135 x 24µm.

5. Additional *Embellisia* Records.

Other *Embellisia* material identifiable to species among isolates examined since the Simmons 1983 paper on the genus include *E. phragmospora* from *Papaver somniferum* L., India (EGS 36-072 ex IMI 267817); *E. abundans* from *Hordeum vulgare* L., New Zealand (EGS 36-079 & 36-081 ex IMI 270051 and IMI 270053, respectively); and *E. allii* from *Allium sativum* L., Hungary (EGS 38-073 ex I. Walcz BT/108).

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ACKNOWLEDGMENTS

C. F. Hill (Lynfield Plant Protection Centre, Auckland, New Zealand) and J. David (CAB International Mycological Institute, Kew, U.K.) have furnished the abetment essential to development of this additional material on the genus *Embellisia* and its teleomorphs. Their willingness to share isolates and information is valued highly.

G. J. Samuels (National Fungus Collections, Beltsville, MD) has given this material a much appreciated prepublication editing and review, and, quite appropriately, queries the theory and practice of segregating genera primarily or entirely on the basis of anamorph differences, as I have done here in the case of *Allewia* from *Lewia*. The difficulties inherent to this practice are great, particularly with fungus groups in which synanamorphy is known. The taxonomic and identification problems are real; approaches by specialists in different groups vary.

Since Dr. Samuels and I are not alone among mycosystematists who must interpret the approaches of different colleagues, it is pertinent to state my own working hypothesis (in the Pleosporales), which is that distinctive groups of morphologically very diverse anamorphs are related to morphologically conservative but genetically diverse *Pleospora* auct. and *Pyrenophora* auct., and that it is of practical and potentially of general taxonomic value to define (and name) whatever holomorphic segregates can be recognized and defended at the specialist level.

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TAXONOMICAL STUDIES ON USTILAGINALES. VI.*

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ABSTRACT

NEW SPECIES proposed: *Neovossia japonica* Vánky (type on *Alopecurus geniculatus*).

NEW COMBINATIONS proposed: *Neovossia pulcherrima* (Ellis & Gall. ex G.P. Clinton) Vánky, based on *Tilletia pulcherrima* (on *Panicum virgatum* and *Digitaria sanguinalis*). – *Sporisorium ehrenbergii* (Kühn) Vánky, based on *Sorosporium ehrenbergii* (on *Sorghum bicolor*). – *Sporisorium occidentale* (Seymour ex G.P. Clinton) Vánky & Snetselaar, based on *Sphacelotheca occidentalis* (on *Andropogon gerardii*). – *Sporisorium provinciale* (Ell. & Gall.) Vánky & Snetselaar, based on *Sorosporium ellisii* Winter var. *provinciale* (on *Andropogon gerardii*). – *Urocystis asphodeli* (Massenot) Vánky, based on *Tuburcinia asphodeli* (on *Asphodelus ?ramosus*). – *Urocystis clintoniae* (Kom.) Vánky, based on *Tuburcinia clintoniae* (on *Clintonia udensis*).

The following names are considered SYNONYMS: *Sphacelotheca cheoana* Zundel (type on *Eragrostis cilianensis*) and *Ustilago orientalis* Yen (nomen nudum; on *Eragrostis cilianensis*) are *Ustilago spermophora* Berk. & Curtis ex de Toni (type on *Eragrostis cilianensis*).

The *Ustilago hypodytes* group is studied, within which *U. macrochloae* is also distinguished.

ACCEPTED NAME for the corn smut is *Ustilago maydis* (DC.) Corda.

Ustilago digitariae f. *panici-repentis* Kühn is a NOMEN CONFUSUM.

LECTOTYPES are selected for *Tilletia pulcherrima* Ellis & Gall. ex G.P. Clinton (= *Neovossia pulcherrima*), and for *Tolyposporium filiferum* Busse (= *Sporisorium ehrenbergii* (Kühn) Vánky). NEOTYPES are selected for *Anthracoidea liroi* (Lehtola) Nannf., and for *Urocystis galanthi* Pape. A new NEOTYPE is proposed for *Sporisorium sorghi* Ehrenberg ex Link.

EXCLUDED SPECIES: Both *Thecaphora inquinans* Berk. & Br. (type on *Paspalum scrobiculatum*), *Sorosporium lolii* Thümen (type on *Lolium perenne*), and *Ustilago andropogonis-finitimi* Maubl. (type on *Andropogon finitimus*) are *Epicoccum andropogonis* (Ces.) Schol.-Schwarz. – *Tolyposporium montiae* (Rostrup) Rostrup (type on *Montia fontana*) is an ascomycete.

In this paper, further results of my taxonomical and nomenclatorial investigations on smut fungi are presented.

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*Studies in Heterobasidiomycetes, part 79

Neovossia and Tilletia species on Alopecurus.

Among specimens obtained in exchange from Sapporo (SAPA) are two collections of Alopecurus, each with a different Neovossia (in some author's opinion Tilletia) species. One of them is certainly not identical to any previously known Neovossia or Tilletia species (comp., i.a., Durán & Fischer 1961). It is described here.

Neovossia japonica Vánky, sp. nov.

Typus in matrice Alopecurus geniculatus L., Iaponia, Higo (= Kumamuto Pref.), Houtaku-gun, Idemizu-mura, 26.V.1904, K. Yoshino (T. corona). Holotypus in Herbario Ustil. Vánky (HUV 11762!); isotypi in SAPA, et in Herb. Institute of Agriculture and Forestry, Tsukuba, Japan.

Sori (Fig. 1) in nonnullis ovariis, in involucro florali latentes, velati membrana tenui, irregulariter dehiscenti et sic massam nigrescenti–brunneam granuloso–pulveream sporarum demonstranti. Saepe pars proximalis caryopsidis tantum sporis substituta. Sporae (Figg. 2 & 3) globosae usque ellipsoidales, 20–28 x 24–32 µm, flavidae usque rubro-brunneae, pariete 3.5–5.5 µm crasso, dense verrucoso verrucis superne visu irregulariter polyangularibus, in sectione mediana sporarum rotundatis vel truncatis, 1.5–2.5 µm altis et 1–3 µm latis. Rariter papilla hyalina, vel appendix brevis–longius conjunctus cum spora (reliquiae hyphae sporogenae) visibilis. Inter sporas cellulae steriles paucae, hyalinae, ovoideae usque irregulares, saepe compressae vel collapsae, sporis minores (16–22 µm longae), continentes materiam minutissime granulosam, pariete levi, non laminoso, circa 2 µm crasso.

Sori (Fig. 1) in scattered ovaries, hidden by the floral envelopes, covered by a thin membrane which ruptures irregularly disclosing the blackish-brown, granular-powdery mass of spores. Often only the proximal part of the caryopses are replaced by the spores. Spores (Figs. 2 & 3) globose, subglobose to ellipsoidal, 20–28 x 24–32 µm, yellowish- to reddish-brown. Spore wall 3.5–5.5 µm thick provided with coarse warts; warts in surface view irregularly polygonal, scale-like, in median view of the spores rounded or truncate, 1.5–2.5 µm high and 1–3 µm wide. Sheath lacking. Rarely a hyaline papilla or a shorter or longer, thin appendage is attached to the spores (the remnant of the sporogenous hypha). Sterile cells few between the spores, hyaline, ovoid to irregular, often flattened or collapsed, smaller than the spores (16–22 µm long), content very finely granular, wall c. 2 µm thick, not laminated, smooth.

The generic delimitation of Neovossia and Tilletia is unsatisfactorily solved. Further studies, including as many characters as possible of a large number of species, are needed to elucidate this problem.

Other known Tilletia species on Alopecurus are: T. controversa Kühn, T. alopecuri (Sawada) Ling, and T. youngii G.P. Clinton & Zundel. The main differences between these species are presented in form of a key.

1. Spores reticulate .... T. controversa
– Spores otherwise sculpted 2
2. Spores pale yellow, provided with pyramidal tubercles. Sori in seeds and vegetative parts 3
– Spores dark coloured. Sori in seeds only 4
3. Spores 17–25 µm long, tubercles 2–3 µm high .... T. alopecuri
– Spores 21–29 µm long, tubercles 2.5–4 µm high .... T. youngii
4. Spores medium reddish-brown, sheath lacking, tubercles blunt or truncate in median view .... N. japonica
– Spores dark reddish-brown, sheath present, tubercles acute in median view .... N. sp. ignota

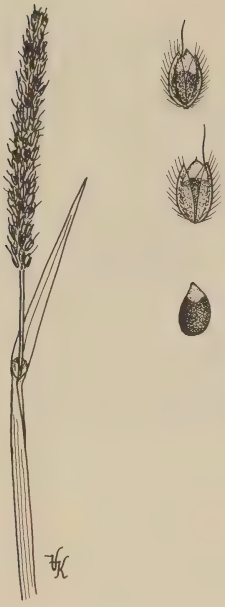

Fig. 1. Sori of Neovossia japonica in scattered ovaries of Alopecurus geniculatus. Partial infection of the seeds is visible on isolated sori.

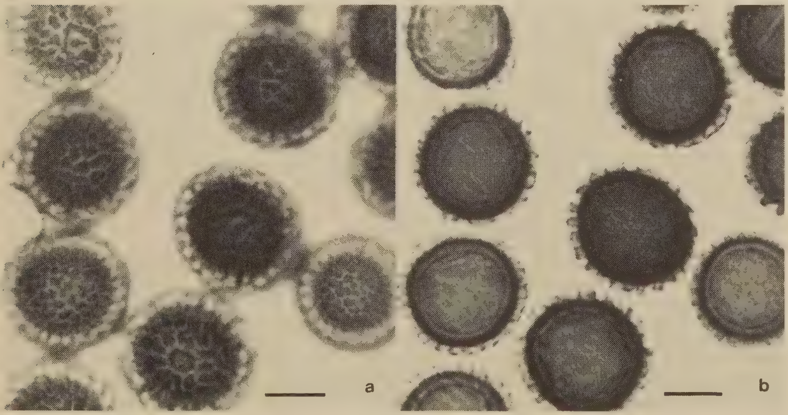

Fig. 2. Spores of N. japonica (type) in LM, in surface view (a), and in optical median view (b). (Bars = 10 μm).

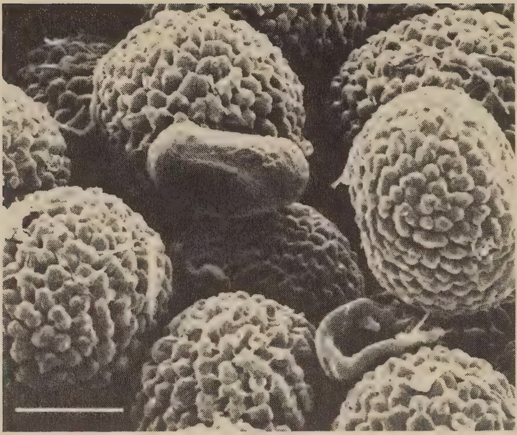

Fig. 3. Spores and two collapsed sterile cells of N. japonica (type) in SEM. (Bar = 10 µm).

NEW COMBINATIONS PROPOSED

Sporisorium ehrenbergii (Kühn) Vánky, comb. nov.

Basionym: Sorosporium ehrenbergii Kühn, Mitth. Vereins Erdk. Halle, 1877:87 . – Tolyposporium ehrenbergii (Kühn) Patouillard, 1903:254. – Type on Sorghum cruentum (Ard.) Host (= S. bicolor (L.) Moench), Egypt, Cairo.

Tolyposporium filiferum Busse, 1905:383. – Sorosporium filiferum (Busse) Zundel, 1930:148. – Lectotype on Andropogon sorghum (L.) Brot. var. densissimus Busse & Pilger (= S. bicolor (L.) Moench), Tanzania, Ugogo, VIII.1900, W. Busse (sel. here) No. 278 (EA!); syntypes W. Busse No. 278a & 1182c (EA!).

Sori in occasional ovaries, cylindrical, elongate, often curved, 0.3–1 x 1–3 cm, covered by a thick, smooth, whitish to yellowish-brown membrane (peridium) which fissures apically or longitudinally to expose the black, granular mass of spore balls intermixed with several, long, often ramified, dark brown shreds ("columellae"). Spore balls variable in form and size, subglobose to oblong or irregular, 40–100(–150) µm long, rather permanent, many spored, dark brown, opaque. Spores globose or, more commonly, subpolyhedral, 9–12 x 9.5–15 µm, outer spores dark brown, verrucose on the free surface, inner spores light yellowish-brown, thin-walled, smooth. Columellae composed of host tissues and fungal cells, peridium composed of chains of elongated, hyaline fungal cells, ovoid to long cylindrical, 10–50 µm long.

On Gramineae: Sorghum spp., Africa, Asia.

Sporisorium occidentale (Seymour ex G.P. Clinton) Vánky & Snetselaar, comb. nov.

Basionym: Sphacelotheca occidentalis Seymour ex G.P. Clinton "(Seymour) G.P. Clinton", 1902:141, nomen nudum; 1904:389. – Sorosporium ellisii Winter var. occidentalis Seymour, in Ellis & Everhart, North American fungi No. 2265, Febr. 1889 (nomen nudum). – Type on Andropogon furcatus Muhl. in Willd. (= A. gerardii Vitman), USA, North Dakota, Bismarck, 30.VIII.1884, A.B. Seymour (BPI 69513!, HUV 1980!); isotypes in Ell. & Ev., N. Amer. fgi. 2265/a (HUV 12914!).

Sori in florets as light brown, cylindrical bodies, 1–1.5 x 5–10 mm, rarely larger, first covered by a thick fungal membrane which then ruptures irregularly to disclose the blackish-brown, semiagglutinated mass of spores and a central columella derived from host vascular tissue. Spore balls loose, early disarticulating. Spores slightly irregular, subpolyhedral, ovoid to elongate, 12–16 x 13.5–18.5 µm, yellowish-brown; wall thin (c. 0.5 µm), uniform, finely and densely punctate-echinulate, spore profile finely serratulate. Sterile cells between the spores in groups or chains, very variable in shape and size, usually smaller than the spores (8–15, rarely up to 22 µm long), collapsed in old specimens, hyaline, with a few oil droplets, wall thin (c. 0.5 µm), smooth.

Sporisorium provinciale (Ellis & Galloway) Vánky & Snetselaar, comb. nov. Basionym: Sorosporium ellisii Winter var. provinciale Ellis & Galloway, J. Mycol. 6:31, 1890. – Sorosporium provinciale (Ell. & Gall.) G.P. Clinton, 1902:145. – Lectotype on Andropogon provincialis Lam. not Retz. (= A. gerardii Vitman), USA (sel. by Clinton 1902:145), Montana, Saline Co., near Emma, 3.VI.1889, C.H. Demetrio (BPI 179762); isolectotypes in Ellis & Ev., N. Amer. fgi. 2425 (as Sorosporium ellisii; HUV 5231). Syntype on A. provincialis, USA, Nebraska, Custer Co., 1889, H. Webber (BPI 179759).

Sori cylindrical, 2–5 mm wide, up to 12 cm long, in the axis bearing the inflorescence branches, which are sometimes seen in atrophied form at the apex. Sori emerge from the leaf sheath, initially enclosed in a light brown peridium which later becomes lacerated, exposing the black-brown, granular-powdery mass of spore balls and the interwoven and interconnected remnants of host vascular tissue. Spore balls globoid to elongated or somewhat irregular, 25–55 x 30–75 µm in diameter, composed of a few (5) to many (35 or more?), loosely connected, rather uniform spores. Spores subglobose, ovoid or slightly irregularly subpolyhedral, 12–16 x 13–19 µm, medium reddish-brown though often darker in places; wall 3–4 µm thick, surface minutely and densely verruculose-echinulate.

On Gramineae: Andropogon spp., North America.

Urocystis asphodeli (Massenot) Vánky, comb. nov.

Basionym: Tuburcinia asphodeli Massenot, in Guyot, Malençon & Massenot, Rev. Pathol. Vég. Entomol. Agric. France 34:196, 1955. – Type on Asphodelus ?cerasiferus Gay (= A. ?ramosus L.; det. Ch. Sauvage), Morocco, Mt. Moyen Atlas, Aguelmane Sidi Ali, 7.VI.1934, G. Malençon (PC!).

Sori in leaves, pustular, isolated or confluent, initially lead-coloured, covered by the epidermis, later black, pulverulent. Spore balls globose or subglobose, 14–31 x 16–38 µm, composed of 1–2(–3) spores, incompletely to completely invested by sterile cells. Spores globose, subglobose to ovoid or slightly irregular, (10–)12–15(–17) x (13–)14–18(–20) µm, reddish-brown. Sterile cells usually collapsed, rarely globose or ellipsoidal, (2–)3–4(–5) x (4.5–)7–9(–10.5) µm, pale yellowish-brown, wall up to 1 µm thick, smooth. Known only from the type collection.

Urocystis clintoniae (Komarov) Vánky, comb. nov.

Basionym: Tuburcinia clintoniae Komarov, in Jaczewski, Komarov, Tranzschel, Fungi Rossiae exsiccati No. 260. – Type on Clintonia udensis Trautv. & Mey. (Liliaceae), Russia (USSR), Siberia, "Provincia Amurensis. In pinetis circa Kasanski priisk, in valle fl. Sutar, fl. Amur influentis", 12/24.VI.1896, V.L. Komarov; isotypi in Jacz., Kom., Tranz., Fgi. Ross. exs. 260 (HUV 9255!).

This fungus, together with other Tuburcinia or Ginanniella, such as T. orobanches Fr., T. paridis (Unger) Vestergr., T. primulae (Rostr.) Liro, T. primulicola (P. Magnus) Bref., T. trientalis Berk. & Br., possessing permanent spore balls composed of fertile spores surrounded by sterile cells, belongs to the genus Urocystis Rbh. (nomen conserv.). The darker or lighter spore ball color, the different number of spores per spore ball, the variable size of sterile cells, and the presence or absence of a conidial stage are not significant enough characters to mentain two or three separate genera. (comp. also Nagler 1987).

The herbarium name of *Tilletia pulcherrima* Ellis & Galloway, on *Panicum virgatum*, is mentioned, without a description, by Tracy and Earle (1896:210) (nomen nudum). Clinton (1904:441) first described the fungus, mentioning it on "*Panicum obtusatum*, Ariz.; *P. sanguinale*, Miss.; *P. virgatum*, Ill. (type)". Clinton mentioned two exsiccatae: Seymour & Earle, Econ. fgi., Suppl. C. 52, on *Panicum virgatum*, and Seymour & Earle, Econ. fgi. 543, on *Panicum sanguinale* (as *Tilletia rotundata*). The first of these two exsiccatae contains smut on *Panicum virgatum* collected in Illionis. Consequently, the specimen distributed in Seymour & Earle, Econ. fgi., Suppl. C. 52 must be chosen as lectotype of *T. pulcherrima*. That on *P. sanguinale*, distributed in Seymour & Earle, Econ. fgi. 543, is considered syntype.

The study of the lecto- and syntype of *T. pulcherrima* revealed characters of a *Neovossia* (comp. Vánky 1987:82).

Neovossia pulcherrima (Ellis & Galloway ex G.P. Clinton) Vánky, comb. nov. Basionym: *Tilletia pulcherrima* Ellis & Galloway ex G.P. Clinton, 1904:441. – Lectotype on *Panicum virgatum* L., USA, Illionis, (sel. here) Champaign, 8.IX.1897, coll. G.P. Clinton (HUV 9647); isolectotypes in Seymour & Earle, Econ. fgi., Suppl. C. 52. Syntype on *Panicum sanguinale* L. (= *Digitaria sanguinalis* (L.) Scop.), USA, Miss., Starkville, 7.X.1895, S.M. Tracy (HUV 9811); isosyntypes in Seymour & Earle, Econ. fgi. 543 (as *Tilletia rotundata*).

Sori in scattered ovaries, ovoid, c. 2 mm long, covered by a brown membrane which ruptures disclosing the black, powdery spore masses. Spores globose to ovoid, 20–28(–32) x (20–)22–28(–32) µm, dark chestnut-brown, opaque; wall 2.5–3.5 µm thick, provided with densely situated coarse warts; warts in surface view irregularly polygonal, in median view in young spores acute, in mature ones blunt, 1–1.5 µm high equalling the hyaline sheath, which sometimes tapers into a short appendage, the remnant of the sporogenous hypha. Sterile cells between the spores hyaline, smaller than the spores (12–20 µm long), globose, ovoid to pyriform; wall smooth, 1–2.5 µm thick, often with a short appendage.

Panicum virgatum takes another smut with tuberculate spores: *Tilletia maclagani* (Berk.) G.P. Clinton (syn. *T. rotundata* (Arthur) Massee). The spore mass in *T. maclagani* is orange-brown, the spores are light orange-yellow, variable in form and size, 17–28(–32) µm long; spore wall 2.5–3.5 µm thick, adorned copiously with small verruculations, which tend to become blunt with maturity; sheath lacking.

SYNONYMS

Sphacelotheca cheoana (and *Ustilago orientalis*) = *Ustilago spermophora*. The generic position of *Ustilago spermophora* Berkeley & Curtis ex de Toni (type on *Eragrostis cilianensis*) is somewhat uncertain. Moesz (1921:63) transferred it into *Sphacelotheca* because of the presence of a ramified "columella" and sterile cells in the sori. Langdon & Fullerton (1978) concluded that "*Sphacelotheca* is soundly based, and that some species of smuts of the Polygonaceae are correctly placed in that genus". Vánky & Oberwinkler (unpublished) concluded that *Sphacelotheca* species are restricted to hosts in Polygonaceae. Most of the "*Sphacelotheca*" species described on Gramineae possess spore balls, at least in early stages of spore development, and the sori have a well-developed peridium and columella/ae, formed of host tissues and fungal elements. Such species are, or should be placed in *Sporisorium*.

The smut in the ovaries of different *Eragrostis* species has been described several times. Typically, this fungus has sori in scattered ovaries, 1–2 mm in diameter, covered by a membrane of fungal and host origin. The distal part of the sorus often bears a hard, yellowisah-brown, acute body, the intact remnant of the caryopsis. Chains of sterile cells are attached to the inner part of the sorus membrane (illustrated by Moesz, 1921:64, 1950:120). The "columella" in this fungus is formed only of fungal tissue (Moesz 1921:63). Spore balls could not be observed. Consequently, this species does not belong to *Sporisorium*.

A comparison of the types of *Sphacelotheca cheoana* and *Ustilago* spermophora revealed no essential differences between the two. Variation in the spore size and ornamentation (Yen (1935:7), lies within the variability of this species and does not merit specific rank. I found that spores of the type of S. cheoana measured 6.5–9.5 x 8–11 µm, spores of the type of U. spermophora measured 6.5–9 x 8–10.5 µm, and spores of a specimen from Transylvania (Vánky, Ust. 14) measured 7–10 x 8–13 µm. Spores of a hungarian specimen of Sphacelotheca spermophora were 7.5–9 x 7.5–10.5 µm (Moesz 1921:63). Consequently, the name and synonyms of this fungus are:

Ustilago spermophora Berkeley & Curtis ex de Toni, in Saccardo (1888:466). – Ustilago spermophora Berkeley & Curtis, in Curtis, 1867:123 (as "spermophorus"; nomen nudum). – Sphacelotheca spermophora (Berk. & Curtis) Moesz, 1921:63. – Type on Eragrostis poaeoides Beauv. var. megastachya (= E. cilianensis (All.) Janchen), USA, Iowa, Charles City, IX.1882, J.C. Arthur; isotypi in Ellis, N. Amer. fgi. 1098 (as U. spermophorus; HUV 10545!).

Ustilago kusanoana P. Hennings, 1904:140. – Sphacelotheca kusanoana (P. Henn.) P. Hennings, 1905:594. – Cintractia kusanoana (P. Henn.) Shirai, 1905:20. – Type on Eragrostis ferruginea Beauv., Japan, Tokio, IX.1901, S. Kusano (350; S!).

Ustilago orientalis Yen, 1935:7 (nomen nudum). – Ustilago spermophora Berk. Curtis var. orientalis (Yen) Yen, 1937:187 (comb. illeg.). On Eragrostis cilianensis, China, Nanking, near Lingkutze, IX.1930, T.-N. Liou (PC).

Sphacelotheca cheoana Zundel, 1943:168. – Type on Eragrostis cilianensis (All.) Janchen, China, Prov. Anhwei, Chu Hua Shan, Ch'ing Yang Hsien, Sha Kan, 24.X.1932, S.Y. Cheo (1395; BPI!).

About the "culm smuts" of Gramineae.

Having studied some of the "culm smuts" of the Gramineae (Vánky 1985:216) and within the Ustilago hypodytes complex I recognize the following species: 1) U. minima Arthur, characterised by the presence of peridium and small (3.5–6 µm), smooth spores lacking polar caps; 2) U. williamsii (Griff.) Lavrov, having relatively large (6–10 µm), smooth spores with two, well-developed polar caps and often, cracked exospore, peridium lacking; 3) U. halophila Speg., possessing peridium and relatively large (4–8 µm), smooth spores with uniformly thickened wall lacking polar caps; and 4) U. hypodytes s. str., without peridium, with relatively medium-sized (3.5–7 µm), smooth or very finely punctate spores and small to more or less well-developed, medium-sized polar caps in some of the spores.

Recent study of U. stipae-barbatae R. Maire revealed that it is indistinguishable from U. halophila Speg. (Vánky 1988a:372).

Ustilago macrochloae Patouillard (1906:199), syn. Sphacelotheca macrochloae (Pat.) R. Maire (1916:279), is another smut belonging to the U. hypodytes group, which can not be enrolled in any of the above-mentioned species. Type on Stipa tenacissima L. (syn. Macrochloa tenacissima (L.) Kunth), Algeria, on the plains between Ben Ikrou and Founassa.

Sori usually destroy the whole panicle. Sori are long cylindrical with short, adpressed branches and remnants of floral envelopes, first covered by a well-developed peridium which flakes away to reveal the dark brown, semi-powdery mass of spores and remnants of floral axis and branches. Spores globose, subglobose or, most commonly, more or less ellipsoidal, 5.5–7 x 6–8 µm, yellowish-brown; wall very finely punctate, often bipolarly thickened. On Stipa tenacissima L., N. Africa.

Ustilago jacksonii Zundel & Dunlap, in Zundel, 1939:982 (type on Stipa lettermanii Vasey, USA, Colorado, Tolland, 13.VIII.1921, E. Bethel, comm. H.S. Jackson as U. hypodytes) is another culm smut, characterised by its large, verruculose spores.

To this group of smuts also belongs Ustilago sparti Massenot, in Guyot, Malençon & Massenot, 1955:215, with sori in the inflorescence of Lygeum spartum L. (comp. also Vánky, 1988:404).

The main differentiating characters of these species are:

species	sori	peridium	spore size	wall	polar caps
U. minima	on culms	+	3.5-6	smooth	-
U. halophila	on culms	+	5-8	smooth	-(+)
U. hypodytes	on culms	-	3.5-7	smooth-punctate	+-
U. sparti	inflor.	-	5.5-8	smooth	-
U. williamsii	culms & inflor.	-	6-10	smooth	+++
U. macrochloae	inflor.	+	5.5-8	punctate	+-
U. jacksonii	culms & inflor.	-	10-14	verruculose	-

Ustilago maydis or Ustilago zeae?

In the most recent papers there are still discussions and no uniformity regarding the use of the name and authorship of the corn smut fungus. The oldest name is that of Lycoperdon zeae Beckmann, 1768:1330 (type on Zea mays, Europe). De Candolle (1815:77) described this fungus under the name Uredo maydis DC. (type on Zea mays, France). The third name for this fungus is that of Uredo /Subgen./ Ustilago zeae Schweinitz, 1822:71 (type on Zea mays (cult.), USA, Carolina.

Corda (1842:3) transferred De Candolle's name into Ustilago: U. maydis (DC.) Corda. "Ustilago maydis (DC.) Léveillé, 1839:12" is wrongly attributed to Léveillé as a new combination (comp. Vánky 1985:222). For De Candolle's fungus, Link created a new name: Caeoma zeae Link, 1825:2 (nomen novum illegitimum; Art. 63.1 of the ICBN). Unger transferred Link's name (and not that of Beckmann's) into Ustilago: U. zeae (Link) Unger, 1836:211 (comb. illegit.).

In accordance with the ICBN (Art. 13; starting point 1st May 1753 for nomenclatorial priority for names of fungi which are not sanctioned) the oldest validly published name for the corn smut is Lycoperdon zeae Beckmann. This name, however, can not be transferred into Ustilago, where it belongs because the name Ustilago zeae is preoccupied by U. zeae (Link) Unger, irrespective of whether is a legitimate name (Art. 64.1, Note 1 of the ICBN). Consequently, the next valid binomial, Ustilago maydis (DC.) Corda, must be accepted.

Ustilago digitariae f. panici-repentis Kühn = nomen confusum.

Vánky (1990:477) reported that Uredo digitariae Rabenhorst (in Rbh., Herb. viv. myc. ed. 2, No. 1199) is actually Ustilago cynodontis (P. Henn.) P. Henn. on Cynodon dactylon.

Kühn (1876:5) described Ustilago digitariae f. panici-repentis, originating from Malaga and concluded that it was identical to Rabenhorst's U. digitariae.

A specimen in HUV (No. 10266), labelled as Ustilago digitariae on Panicum repens, Malaga, 16.X.1875, coll. Dr. Walffenstein is apparently an isotype of Kühn's Ustilago digitariae f. panici-repentis Kühn. The specimen (badly damaged by insects) contains spores of two different smut fungi. One is undoubtedly U. cynodontis on Cynodon dactylon. This Kühn correctly considered to be identical to Rabenhorst's U. digitariae (= U. cynodontis), presenting smooth, 6.5–8.5 µm long spores. The other, having finely and sparsely punctate spores 5–7 µm in diameter, may be identical to Sporisorium formosanum (Sawada) Vánky (Ustilago formosana Saw.), on Panicum repens L.

NEOTYPES

Lehtola (1940:46) described Cintractia liroi "in ovariis Caricis Goudenowii Gay in Fennia". No special collection (type) has been designated for it, and no original material is to be found in H. Lehtola's personal herbarium has been destroyed by fire. I propose as neotype the sample on "Carex rigida" Good. (= C. bigelowii x nigra; comp. Nannfeldt & Lindeberg, 1965:206), Finland, Lapponia enontekiensis, Kilpisjärvi, VII.1934, H. Roivainen & J.I. Liro (HUV 158!); isoneotypes in Liro, Mycoth. fenn. 104 (as Cintractia caricis).

The type of *Urocystis galanthi* Pape, 1923:335, (on *Galanthus nivalis* L., Germany, Berlin, Zehlendorf, I.1921, H. Pape) was lost in Berlin (B) during the second world war (Prof. H. Scholz, in litt.). As neotype is proposed a collection on *Galanthus nivalis* L., Germany, Bayern, Dillingen/Donau, garden of the Kapuziner Kloster, 1.V.1987, B. & F. Oberwinkler, A. Nagler, U. & K. Vánky (HUV 13318!); isoneotypes in Vánky, Ust. 624.

New neotype for *Sporisorium sorghi* Ehrenberg ex Link.

Link (1825:86) described *Sporisorium sorghi* in the seeds of *Sorghum vulgare* Pers. (= *S. bicolor* (L.) Moench) from Egypt, collected by C.G. Ehrenberg. The type, preserved in Berlin (comp. Kühn 1877:86), evidently no longer exists. Therefore, Langdon & Fullerton (1978:450) selected for this species a neotype on *Sorghum leiocladum* (Hack.) Hubb., Australia, Queensland, Killarney, 6.I.1966, R.A. Fullerton (BRIU 2426; isoneotype HUV 7177!). This specimen is, in my opinion, *Sporisorium cruentum* (Kühn) Vánky, presenting, i.a., minutely echinulate spores of 7–8.5 x 7–10 µm diameter. Therefore, I am proposing for neotype of *Sporisorium sorghi* a collection from Egypt, on *Sorghum bicolor*, distributed in Thümen, Mycoth. univ. 725 (as *Ustilago reiliana* Kühn f. *Sorghi cernui*, on *Sorghum cernuum*, Cairo, VI. 1876, G. Schweinfurth; HUV 1672!). Isoneotypes distributed in Thümen, Mycoth. univ. 725. For paraneotype I am proposing a collection on *Sorghum bicolor* from Transylvania (Romania), near Odorhei (Székelyudvarhely), 5.IX.1963, K. Vánky (HUV 2027!), distributed in Vánky, Ustilaginales exs. 50 (as *Sphacelotheca sorghi* on *Sorghum vulgare*).

The main characters differentiating *S. sorghi* and *S. cruentum* are:
Sporisorium sorghi: peridium thick, rather persistent; spores 5.5–7 x 5.5–8(–8.5) µm, from apparently smooth to sparsely punctate or very finely verruculose; sterile cells about the size of the spores.
Sporisorium cruentum: peridium thin, early dehiscent; spores 6.5–8.5 x 7.5–10 µm, finely and sparsely verruculose to minutely echinulate; sterile cells much larger than the spores.

EXCLUDED SPECIES

Three further "smuts" are actually *Epicoccum andropogonis*.

Five described *Thecaphora* species on Gramineae do not belong to the genus *Thecaphora* (Vánky & Berbee 1988:281). Four of them (*T. ammophilae* Oud., *T. andropogonis* Speg., *T. berkeleyana* Fischer v. Waldh., and *T. westendorpii* Fischer v. Waldh.) are not smut fungi. The fifth, *T. herteriana* Cif. is a *Urocystis* (*U. herteriana* (Cif.) Berbee). Ciferri (1924:55) showed that *T. dactylidis* Passerini (type on *Dactylis glomerata* L.), is an *Entyloma* (*E. dactylidis* (Pass.) Cif.). Study of the type specimen of a further "*Thecaphora*" species, *T. inquinans* Berkeley & Broome (1875:94) on *Paspalum scrobiculatum* L., from Ceylon (Sri Lanka), Dolosbagey, V.1868 (BPI 179274!) confirmed the conclusion of Cooke (1889:19) that the fungus is really "*Cerebella paspali* C. & M.", or more exactly *Epicoccum andropogonis* (Ces.) Schol.-Schwarz, a hyphomycete.

Thümen (1880:312) described *Sorosporium lolii* on *Lolium perenne* L., from Yugoslavia, Slovenija, Ljubljana (formerly Austria, Krain = Carniolia, Laibach), 4.XI.1878, W. Voss (HUV 11467!). Liro (1938:324 & 360) believed that *S. lolii* "is only a hyphomycete", maybe a *Sarcinella* or *Stemphylium*, as was *Thecaphora westendorpii* Fischer v. Waldh., (nomen novum illeg. pro *Polycystis lolii* Westendorp). The study of the type showed that it is *Epicoccum andropogonis* (Ces.) Schol.-Schwarz (syn. *Cerebella andropogonis* Ces.).

Maublanc (1906:74) described *Ustilago andropogonis-finitimi* in the ovaries of *Andropogon finitimus* Hochst. (= *Hyparrhenia finitima* (Hochst.) Stapf) from East Africa. The description, the illustration (Fig. 3, pg. 75), together with the caption "*Cerebella* (*Ustilago*) *Andropogonis finitimi*" left no doubt that this species is the hyphomycete *Epicoccum andropogonis* (Ces.) Schol.-Schwarz.

Tolyposporium montiae = ascomycete.

Rostrup (1896:129) described Sorosporium montiae on Montia minor C.C. Gmel. (= Montia fontana L. ssp. chondrosperma (Fenzl) Walters) from Denmark, Zealand, Amager Faelled, VI.1894, C. Ostenfeld Hansen (C). Later, Rostrup (1904:31) himself transferred it into the genus Tolyposporium.

The fungus produces sori in the stems and leaves of Montia and Claytonia species (Portulacaceae). Attacked plants are somewhat dwarfed and affected parts become blackish due to numerous, dark spore balls formed in the host tissues. Spore balls variable in form and size, globose, irregular or elongated, 40–80 µm long, blackish-brown, opaque, composed of numerous, very firmly adhering spores. Spores rounded, ellipsoidal, usually irregularly polyhedral, 5–8 µm long, brown, smooth, thin-walled.

Liro (1938:339), who studied the type specimen, doubted that the fungus is a smut. Doubts were also expressed by Ainsworth & Sampson (1950:112), Zundel (1953:131), Fischer (1953:125), Lindeberg (1959:77), Scholz & Jage (1976), and Scholz & Scholz (1988:322).

From the above description and from Rostrup's (1896:129) statement ("promycelium filiforme, septatum") the fungus sounds very much like a smut. The "promycelium", however, was presumably mycelium present around and between young "spore balls". Study of the structure of very young spore balls, young spores, and of sections of mature spore balls convinced me that this fungus is not a member of the Ustilaginales. Dr. R. Bauer kindly checked the ultrastructure of this fungus and found that the septal pore is simple and Woronin bodies are present demonstrating that the fungus is an ascomycete.

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ABBREVIATIONS

The abbreviations for herbaria follow Index Herbariorum (Stafleu 1981).

HUV = Herb. Ustilag. Vánky, the author's private herbarium.

ICBN = International Code of Botanical Nomenclature.

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CULTURE CHARACTERISTICS OF SOME MYCENA SPECIES

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Summary

Twenty-one species of the genus Mycena (M.acicula, M.alcalina, M.amicta, M.cinerella, M.epipterygia, M.galericulata, M.galopus, M.haematopus, M.maculata, M.metata, M.polygramma, M.pura, M.rorida, M.rosea, M.rosella, M.rubromarginata, M.sanguinolenta, M.stylobates, M.viridimarginata, M.vulgaris and M.zephirus) and Rickenella fibula are described by their culture characteristics on malt agar. The mycelial colonies are characterized with respect to their macroscopic and microscopic features as well as their luminescence behavior and their ability to produce extracellular oxidases. All species produced extracellular oxidases, and seven species (M.galopus, M.haematopus, M.maculata, M.polygramma, M.pura, M.rosea, M.zephirus) showed luminescence. Hyphal swellings are a very common character, and in a few species hyphal strands are formed (M.galericulata, M.metata, M.rosea, M.viridimarginata, M.zephirus). Rickenella fibula and Mycena acicula cultures are very similar and both can be clearly distinguished from all other cultures. Only the spores of Mycena rosea and Mycena pura did not germinate on malt agar. M.galericulata and Mycena galopus were the only species with strain specific variation. A key, using culture characteristics, is provided for all species.

INTRODUCTION

Identification and determination of higher fungi is largely based on morphological and anatomical characters of their generative stage, i.e. their fruitbodies. Only in recent years has the possibility of growing, at least some groups of fungi on artificial media, provided the opportunity to examine specific characteristics of the vegetative mycelia. Accordingly studies have been published providing useful keys for determination of certain groups of fungi (Besl et al. 1989, Miller et al. 1983, Nobles 1958, Nobles 1965, Pantidou & Groves 1966, Stalpers 1978).

Research on fungal cultures is based on a variety of aims. In some cases distinct ecological groups of fungi are involved. Wood inhabiting species were characterized by Nobles (1965) and Stalpers (1978). Besl et al. (1989) and Miller et al. (1983) described some mycorrhizal fungi aimed at providing a key which in future would allow to identify any fungal culture isolated from mycorrhizae.

There are of course also taxonomic approaches in which the study of cultures is intended to contribute to the evaluation of fungal relationships. Kühner (1947) characterized cultures from several species of Homobasidiomycetes. Marr (1979), Miller (1971), Pantidou et al. (1983) and Semerdzieva (1965) described cultures of Agaricales. Aphyllophorales cultures were studied by Nobles (1958, 1971) and by Stalpers (1978). Campbell & Peterson (1975) characterized cultures of some _Amanita_ species. Cultures of _Pleurotus_ were described by Semerdzieva (1966). Species of Boletales were characterized by Besl et al. (1989), Laut (1966), Pantidou (1961) and Pantidou & Groves (1966).

Miller (1971) stressed the necessity to evaluate the cultural behaviour of a wider range of species. In the following study the cultural characteristics of several _Mycena_ species and of _Rickenella fibula_ are described. Until now cultures of _Mycena_ have not been studied comprehensively; physiological aspects, however, have been examined by Fries (1949).

MATERIALS AND METHODS

In these studies malt agar (2% Löflund malt extract, 2% agar) was used as the medium for characterization of the cultures.

Fruitbodies were collected in the field and on the same or the following day used for establishing cultures. These cultures were obtained in most cases from basidiospores in the following manner:

Whole caps, or sections of caps, were fixed with glue on the lid of petri dishes allowing the basidiospores to be discharged onto the agar surface. The caps were removed after several minutes or hours depending on the maturity of the hymenium. Germination followed soon and contaminations were rare. Only two species (_Mycena pura_ and _Mycena rosea_) did not germinate and in those cases cultures were obtained by direct isolation from the fruitbody trama.

Successfully grown cultures were transferred into new petri dishes and characterization of the cultures was carried out by observing the cultures over a period of at least eight weeks after inoculation. If not otherwise stated the descriptions refer to six weeks old cultures.

In addition all strains were tested for extracellular oxidases following the method of Davidson et al. (1938) by transferring them to tannic acid agar (0,4% yeast extract, 1% malt extract, 0.4% glucose, 2% agar, 0,5% tannic acid). A brown zone round the inoculum plug was interpreted as a positive test result.

Luminescence was tested visually every five days for ten minutes in total darkness.

For microscopical examination small pieces were removed from the agar, bruised, dyed with congo red (saturated solution in water) and washed with a solution of potassium hydroxide (10%). For each strain at least three petri dishes have been examined. From some of the cultures longitudinal sections were made by cutting thin slices with a razor blade (vertical to agar surface).

The cultures were stored at room temperature in diffuse daylight. The drawings were made with a ZEISS standard microscope with the aid of a camera lucida. The magnification was 1250 x.

Species determinations were carried out with reference to the works of Kühner (1938), Maas Geesteranus (1980a, 1988), Moser (1978) and Smith (1947). The nomenclature refers to Maas Geesteranus (1980a, 1980b, 1988), Maas Geesteranus & Schwöbel (1987), Michael et al.(1987) and Moser (1978).

Specimens studied:

Mycena acicula (TR 755, 15.5.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena alcalina (TR 757, 10.6.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 961, TR 962, 14. 5.85): FRG, Bavaria, Forstenrieder Park, MTB 7934.- Mycena amicta (TR 754, 22.8.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena cinerella (TR 169, 11.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena epipterygia (TR 170, 11.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 178, 18.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena galericulata (TR 151, 30.10.84): FRG, Bavaria, Högelwald, Lkrs. Aichach, MTB 7732; (TR 966, 22.5.85): FRG, Bavaria, Munich, Kapuzinerhölzl, MTB 7834; (TR 967, 22.5.85): FRG, Bavaria, Munich, Hartmannshofer Park, MTB 7834. - Mycena galopus (TR 964, 19.7.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 134, 14.10.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 975, 11.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena haematopus (TR 37, 18. 9.84): FRG, Bavaria, Thalham, north of Miesbach, MTB 8136, leg. F. Brand. - Mycena maculata: (TR 182, TR 188, 9.12.84): FRG, Bavaria, Munich, Allacher Lohe, MTB 7734; (TR 189, TR 190, 16.12.84): FRG, Bavaria, Munich, Allacher Lohe, MTB 7734. - Mycena metata (TR 90, 28.9. 84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 115, 2.10.84): FRG, Bavaria, Schöngeisinger Forst near Fürstenfeldbruck, MTB 7833; (TR 138, TR 139, 14.10.84):FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena polygramma (TR 185, 9.12.84): FRG, Bavaria, Munich, Allacher Lohe, MTB 7734. - Mycena pura (TR 136, 14.10.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 162, 4.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena rorida (TR 968, 13.8.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena rosea (TR 969, 19.8.84): FRG, Bavaria, Thalham, north of Miesbach, MTB 8136, leg. F. Brand. - Mycena rosella (TR 963, 18.11.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena rubromarginata (TR 752, 13.8.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 970, 22.8.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena sanguinolenta (TR 974, 19.7.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena stylobates (TR 971, 28.8.84): FRG, Bavaria, Forstenrieder Park, MTB 7934; (TR 972, 28.9.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena viridimarginata (TR 973, 22.7.84): FRG, Bavaria, Forstenrieder Park, MTB 7934. - Mycena vulgaris (TR 116, 2.10.84): FRG, Bavaria, Schöngeisinger Forst near Fürstenfeldbruck, MTB 7833. - Mycena zephirus (TR 59, 25.9.84): FRG, Bavaria, Lkrs. Aichach, MTB 7732. - Rickenella fibula (TR 965, 16.12.84): FRG, Bavaria, Munich, Allacher Lohe, MTB 7734.

All specimens are preserved in Herbar R.Treu, Munich (M).

RESULTS

In many of the cultures described here some hyphae displayed characteristic swellings with a variable diameter. They could be found singly or in chains (beaded). In the latter case the term moniliform hyphae has been applied.

In some cultures hyphal strands grew out from the agar surface.

Most of the species showed a comparable growth rate; the margin of the petri dishes was reached after three to six weeks; only if the growth rate was significantly slow was it valued as a useful characteristic.

Key for the described species based on cultural characteristics

(The specimen number was added only in the cases where different strains of one species showed deviating cultural characteristics)

1 Cultures with a dark brown diffusion zone in malt agar

2 Cultures not luminescent; with concentric, grey and brown circles around the inoculum plug. Most hyphae with a uniform diameter of 1-2 µm, without hyphal swellings.

M.rosella

2' Cultures luminescent. Surface mycelium whitish, sometimes with reddish brown spots; concentric circles lacking; with hyphal swellings.

M.maculata

1'Cultures without a diffusion zone in malt agar.

3 Cultures with a distinct pigmentation on most of the surface.

4 Pigmentation light blue

M.amicta

4'Pigmentation yellow or brownish

5 Cultures with yellow, rarely brownish spots. Other parts of surface mycelium whitish, often with concentric circles; surface mycelium can't be pulled off. Margin of colonies under the agar surface feathery. Strong luminescence. With hyphal swellings. Older cultures with hyphal strands.

M.zephirus

5'Most of the surface with dark yellow surface mycelium which can be pulled off. Margin of colonies not feathery. Without hyphal swellings; no hyphal strands. No luminescence.

M.rubromarginata

3'Even older cultures white, whitish, at most with small, colored spots.

6 Without hyphal swellings or hyphal swellings not very distinct (less than 2,5 x hyphal diameter). No luminescence.

7 Cultures without clamp connections.

M.galericulata (TR 966, TR 967)

7'Cultures with clamp connections

8 Surface mycelium very flimsy. Microscopically with epidermoid surface view.

M.stylobates

8'Cultures with a distinct surface mycelium. Surface without epidermoid structure.

9 Surface mycelium thin, not fluffy

M.vulgaris

9'Surface mycelium thick and fluffy

10 Older cultures form hyphal strands

M.viridimarginata

10'Cultures without hyphal strands.

M.cinerella
M.epipterygia

6'Hyphae with one or more (some hyphae up to 30) swellings (moniliform hyphae). Diameter of swellings more than 2,5 x diameter of hyphae. Cultures luminescent or not.

11 Hyphal swellings oval and single; their diameter up to 15 µm. Agar surface appears speckled.

M.rorida

11'Cultures with hyphal swellings or moniliform hyphae. Swellings never oval, with a diameter less than 15 µm. Agar surface not speckled.

12 Cultures luminescent

13 The fungus causes a hardening of the agar. Spores don't germinate on malt agar

14 Cultures with hyphal strands. Sometimes with a radish-like smell.

M.rosea

14'Cultures without strands and without smell

M.pura

13'Without hardening of agar. Spores do germinate on malt agar

15 Margin of colonies below agar surface feathery

16 Cultures with whitish surface mycelium in concentric rings; with yellow or brownish spots. Older cultures with hyphal strands.

M.zephirus

16'Cultures first snow white, later sometimes slightly brownish but never yellow. Without hyphal strands. Some hyphae with thickened walls.

M.polygramma

15'Margin of colonies below agar surface not feathery

17 Hyphal swellings and moniliform hyphae very abundant. Luminescence strong

M.galopus (TR 964, TR 975)

17'Hyphal swellings present but not very abundant, moniliform hyphae very rare. Luminescence weak.

M.haematopus

12'Cultures without luminescence

18 Growth of colonies in radial direction limited, not exceeding 3 cm; growth slow; young colonies with felty surface which becomes smooth in age. Colors ochre to pale orange; colonies extending over the agar surface.

19 Clamp connections lacking. Hyphae of old cultures with resinous exudates.

M.acicula

19'Clamp connections present; hyphae without exudates.

Rickenella fibula

18'Growth of colonies in radial direction not limited. Growth slow. Surface more or less fluffy. Colors of colonies never orange or ochre. Colonies don't extend over the agar surface.

20 Clamp connections lacking

21 Cultures with hyphal strands

M.galericulata (TR 151)

21'Hyphal strands lacking

M.alcalina

20'Clamp connections present

22 Colonies with hyphal strands

M.metata

22'Colonies without strands.

M.sanguinolenta
M.galopus (TR 134)

Description of the cultures

The cultures studied are arranged in an alphabetical order. The hyphal diameter was very variable and thus was not included in most of the descriptions.

Mycena acicula (Schff.: Fr.)Kummer, figs.1-4
(TR 755)

The cultures are bright orange to yellow gold. Growth takes place predominantly above the agar surface and cultures extend up to 5 mm height. Growth in radial direction is limited. After reaching 3 cm in diameter the cultures ceased to grow. Growth slow. Surface of the inocula fluffy at first, then becoming smooth.
Microscopically there are chains of round swellings (diam. up to 7 µm) mostly at the surface of the colonies. Inner hyphae often show a bizarre shape. On the surface of some hyphae there are yellow, resinous incrustations.
Mycena acicula was the only species with development of fruitbodies in cultures. Unfortunately the development ceased at an early stage. Clamp connections were not found. No smell. Extracellular oxidases +. Luminescence -.

Mycena alcalina sensu Kühner = *Mycena stipata* Maas G. & Schwöbel, figs.5-7
(TR 757, TR 961, TR 962)

Cultures of this fungus produce a white, fluffy surface mycelium without remarkable features. Clamp connections could not be found. Some hyphae with chains of round swellings (diameter up to 10 µm). No smell. Extracellular oxidases +. Luminescence -.

Mycena amicta (Fr.)Quél., fig.8
(TR 754)

Cultures of this species can be recognized very easily because of the blue color of the fluffy surface mycelium. It reminds one of the blue stipe base of the fruitbodies. With clamp connections. No smell. Extracellular oxidases +. Luminescence -.

Mycena cinerella (Karst.)Karst., fig.9
(TR 169)

Cultures with a thick and fluffy, white surface mycelium. With clamp connections. No smell. Extracellular oxidases +. Luminescence -.

Mycena epipterygia (Scop.: Fr.)S.F.Gray, figs.10-11
(TR 170, TR 178)

Surface mycelium white, thick and fluffy. Some clamp connections are swollen. No smell. Extracellular oxidases +. Luminescence -.

Mycena galericulata (Scop.: Fr.)S.F.Gray, figs.12-20
(TR 151, TR 966, TR 967)

Cultures with a white, fluffy surface mycelium.
One of the strains (TR 151) developed hyphal strands after several months. Hyphae with swellings (10 µm diam.) only in one strain (TR 151). In longitudinal sections there are hyphae or hyphal strands growing out of the agar surface. No clamp connections. No smell. Extracellular oxidases +. Luminescence -. (Fruitbodies of all strains with two-spored basidia).

Mycena galopus (Pers.: Fr.)Kummer, figs.21-23
(TR 134, TR 964, TR 975)

The culture looks very distinctive with its chains of swellings.
Most strains (with the exception of TR 134) with a strong luminescence. Cultures with a distinct white, fluffy surface mycelium which can be partially pulled off. Moniliform hyphae abundant, with regularly arranged swellings (up to thirty on one hypha). Diameter of swellings 5-15 µm. Hyphae with one swelling rare. Clamp connections present. No smell. Extracellular oxidases +.

Mycena haematopus (Pers.: Fr.)Kummer, fig.24
(TR 37)

Surface mycelium whitish, fluffy. Cultures with a weak luminescence.
Hyphae with swellings, their diameter up to 12 µm. Clamp connections present. No smell. Extracellular oxidases +.

Mycena maculata Karst., figs.25-28
(TR 182, TR 188, TR 189, TR 190)

Surface mycelium first white, later dark reddish brown, fluffy. After only a few days a dark brown diffusion zone occurs. Cultures with luminescence. Hyphae in older cultures with swellings (diameter up to 10 µm). Sometimes with cell wall thickenings. Clamp connections present. No smell. Extracellular oxidases +.

Mycena metata (Fr.)Kummer, figs.29-32
(TR 90, TR 115, TR 138, TR 139)

Surface mycelium white, after several months brownish and with small, crater-like surface structures; with hyphal strands growing out of the agar surface; fluffy. Hyphal swellings could be found (diameter up to 12 (20) µm). Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena polygramma (Bull.: Fr.)S.F.Gray, fig.33
(TR 185)

Surface mycelium snow white, fluffy; mycelium with a distinct luminescence. Margin of colony below agar surface feathery. Hyphal swellings or moniliform hyphae present. Diameter of swellings up to 10 µm. Some hyphae with a thickened cell wall. Clamp connections present. No smell. Extracellular oxidases +.

Mycena pura (Pers.: Fr.)Kummer, figs.34-35
(TR 136, TR162)

Cultures with a strong luminescence. Surface mycelium fluffy. The fungus causes the agar to become very hard and compact. Hyphal swellings or moniliform hyphae can be found in great numbers (diameter up to 12 µm). Cultures of this fungus were obtained by isolation from fruitbodies, because the basidiospores didn't germinate on malt agar. Clamp connections present. No smell. Extracellular oxidases +.

Mycena rorida (Scop.: Fr.)Quél., fig.36
(TR 968)

Cultures with a white, speckled surface mycelium, fluffy. There are large, oval hyphal swellings with a diameter up to 15 µm. Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena rosea (Bull.)Gramberg, figs.37-38
(TR 969)

The cultures display a radish-like smell, the same as the fruitbodies. The fungus causes the agar to become hard and compact. Surface mycelium fluffy. There is also a strong luminescence. Hyphal swellings and moniliform hyphae are abundant (diameter up to 10 µm). Cultures develop strands growing from the surface. Clamp connections present. The basidiospores of this species don't germinate on malt agar. Extracellular oxidases +.

Mycena rosella (Fr.)Kummer, fig.39
(TR 963)

Cultures of this fungus develop fluffy, concentric, brown and grey colored circles around the inoculum. They remind of an animal's fur. Malt agar is stained dark brown.
The hyphae are very uniform, most of them with a diameter of 1-2 µm and without striking features. Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena rubromarginata (Fr.: Fr.)Kummer, figs.40-41
(TR 752, TR 970)

Two weeks after inoculation the white, fluffy surface mycelium forms yellow spots which increase rapidly and cover most of the surface two weeks later.
Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena sanguinolenta (A.& S.: Fr.)Kummer, fig.42
(TR 974)

The cultures form a white, fluffy surface mycelium. Moniliform hyphae abundant (diameter up to 8 µm). Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena stylobates (Pers.: Fr.)Kummer, figs.43-48
(TR 971, TR 972)

Mycelium white, submerged, only sparce surface mycelium. Microscopically there is an epidermoid surface structure. Longitudinal sections reveal that it is formed by upwards growing hyphae which broaden at their apex and become lobed. Above there is a layer of thin horizontal hyphae with colorless exudates. At the center of the colonies there is a second epidermoid layer further below. Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

Mycena viridimarginata Karst., fig.49
(TR 973)

Surface mycelium white, thick and fluffy, with few hyphal strands growing from the surface.
Clamp connections present, slightly swollen. No smell. Extracellular oxidases +. Luminescence -.

Mycena vulgaris (Pers.: Fr.)Quél., fig.50
(TR 116)

Mycelium white, thin, appressed.
Clamp connections present. No smell. Extracellular oxidases +. Luminescence -.

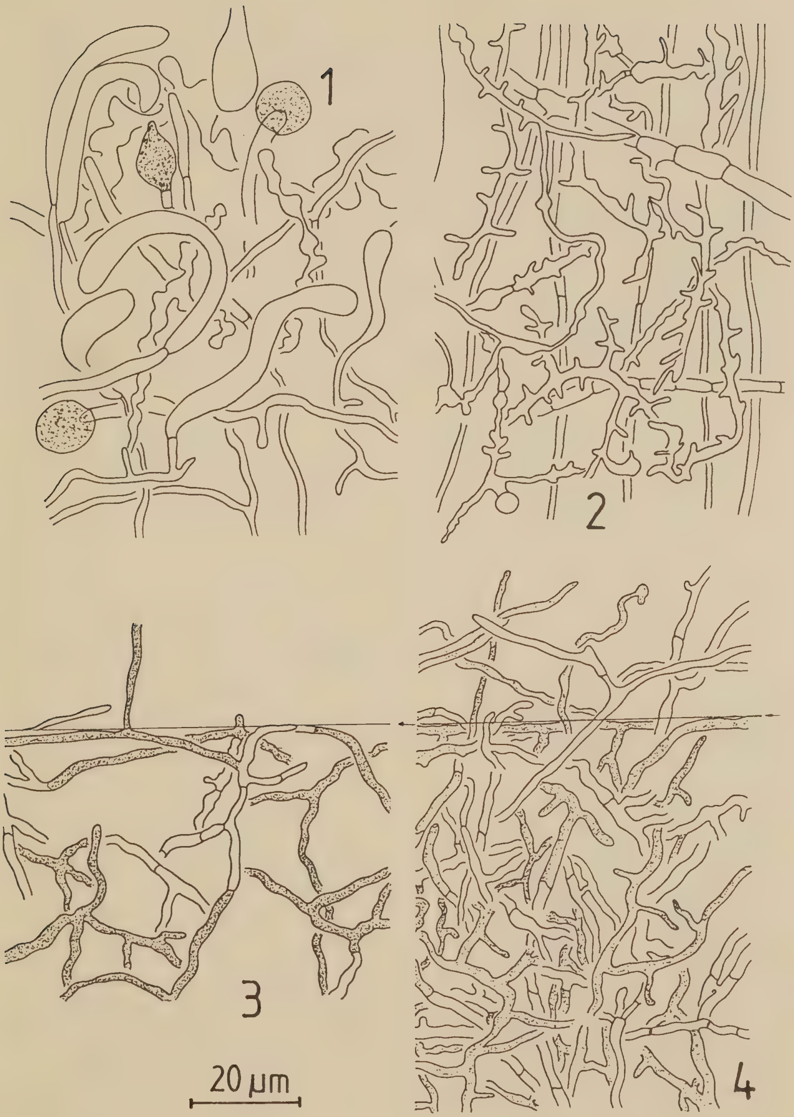
Mycena zephirus (Fr.: Fr.)Kummer, fig.51
(TR 59)

Mycelium luminescent. Surface mycelium fluffy, white and often with concentric rings. After several weeks yellow or brown spots appear. The margin of the colonies below the agar surface is feathery. There are some hyphal swellings with a diameter up to 10 µm. Hyphal strands occur. In older cultures they may become brown. Clamp connections present. No smell. Extracellular oxidases +.

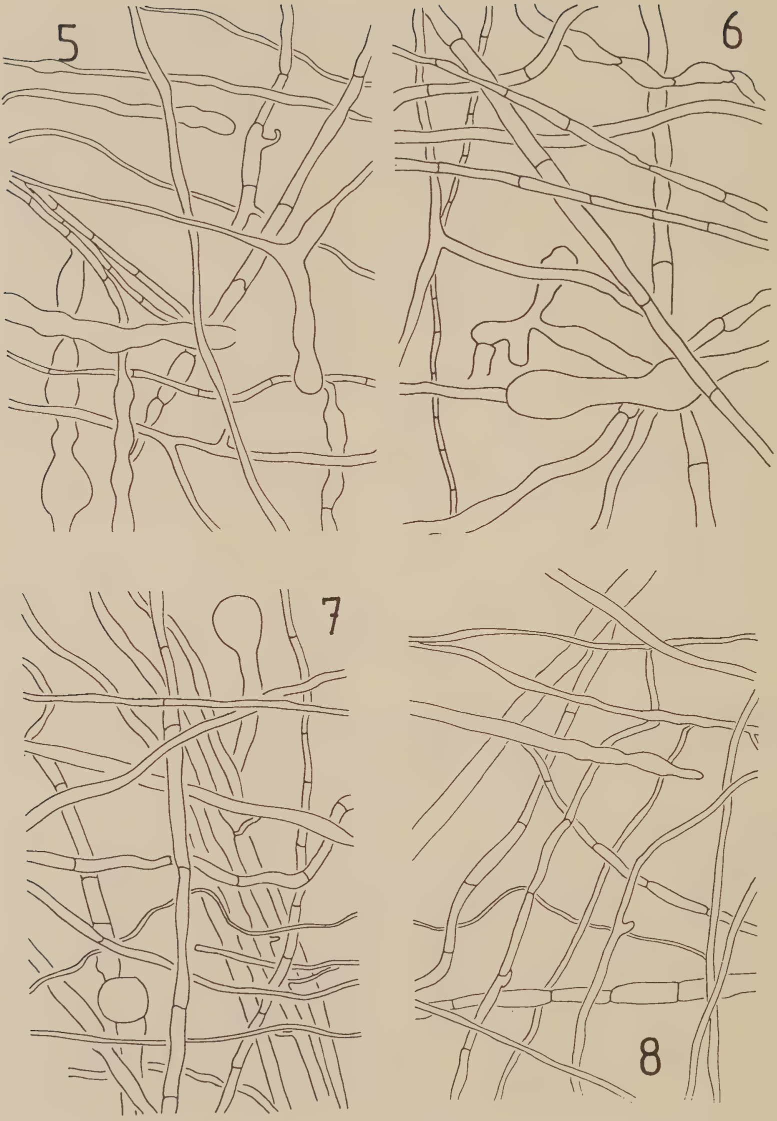
Rickenella fibula (Bull.: Fr.)Raith., fig.52
(TR 965)

The cultures are bright orange to golden yellow. Growth takes place predominantly above the agar surface and cultures expand up to 5 mm height. Growth in radial direction is limited. After reaching 3 cm the cultures cease to grow. Growth slow. Surface of the colonies fluffy at first, then becoming smooth. R.fibula shares these features with Mycena acicula. With moniliform hyphae (diameter up to 10 µm) and clamp connections. No resinous incrustations like in Mycena acicula. No smell. Extracellular oxidases +. Luminescence -.

In the following line drawings dotted hyphae indicate granular contents. In longitudinal sections the agar is always on the bottom.



Figures 1-4: Mycena acicula (TR 755). Fig. 1: surface of colony with resinous exudates. Fig.2: deeper layer with bizarre hyphae. Figures 3-4: longitudinal sections (arrow indicates agar surface). Fig.3: margin of colony. Fig.4: center of colony.



Figures 5-7: Mycena alcalina with hyphal swellings. Fig.5: TR 757. Fig.6: TR 961. Fig.7: TR 962. - Fig.8: Mycena amicta (TR 754)

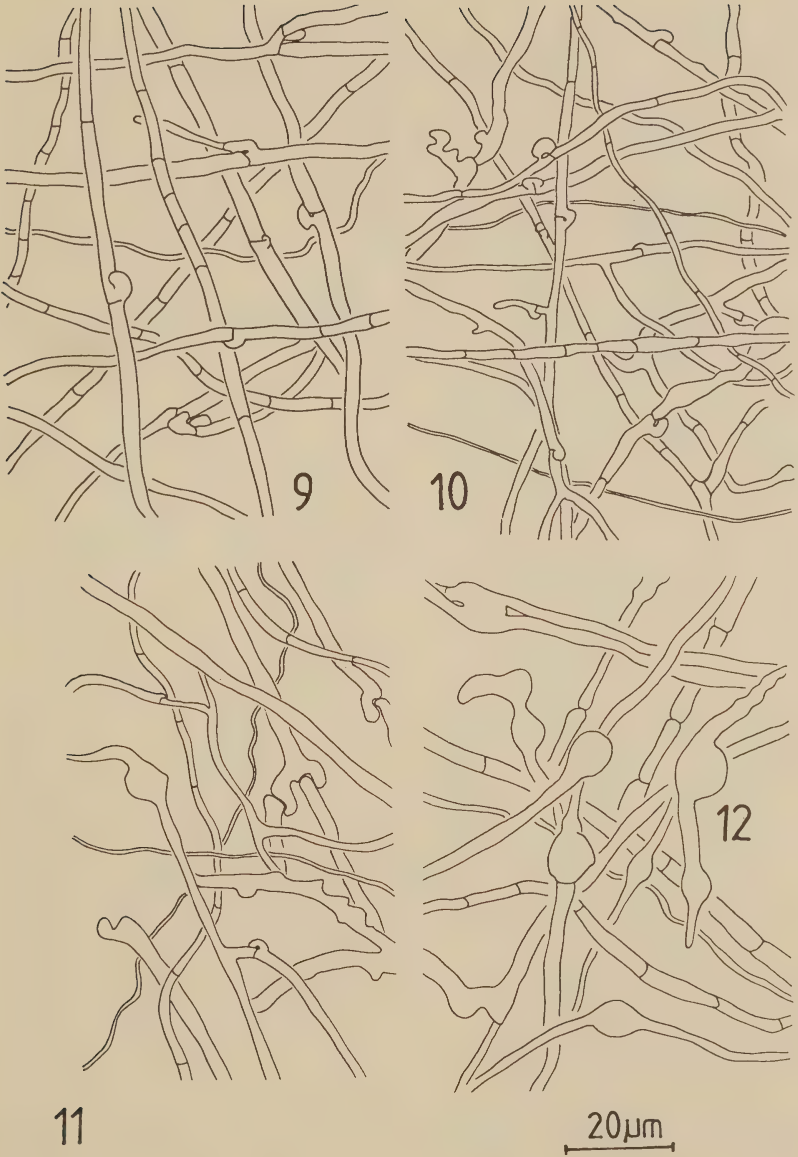
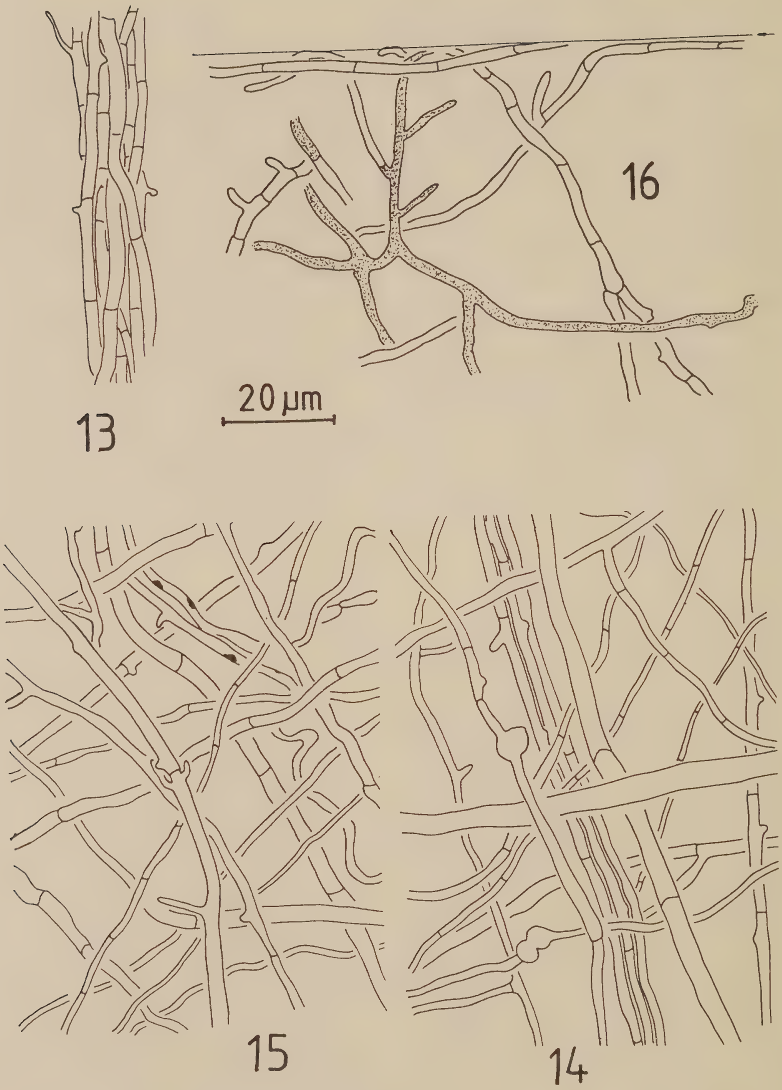
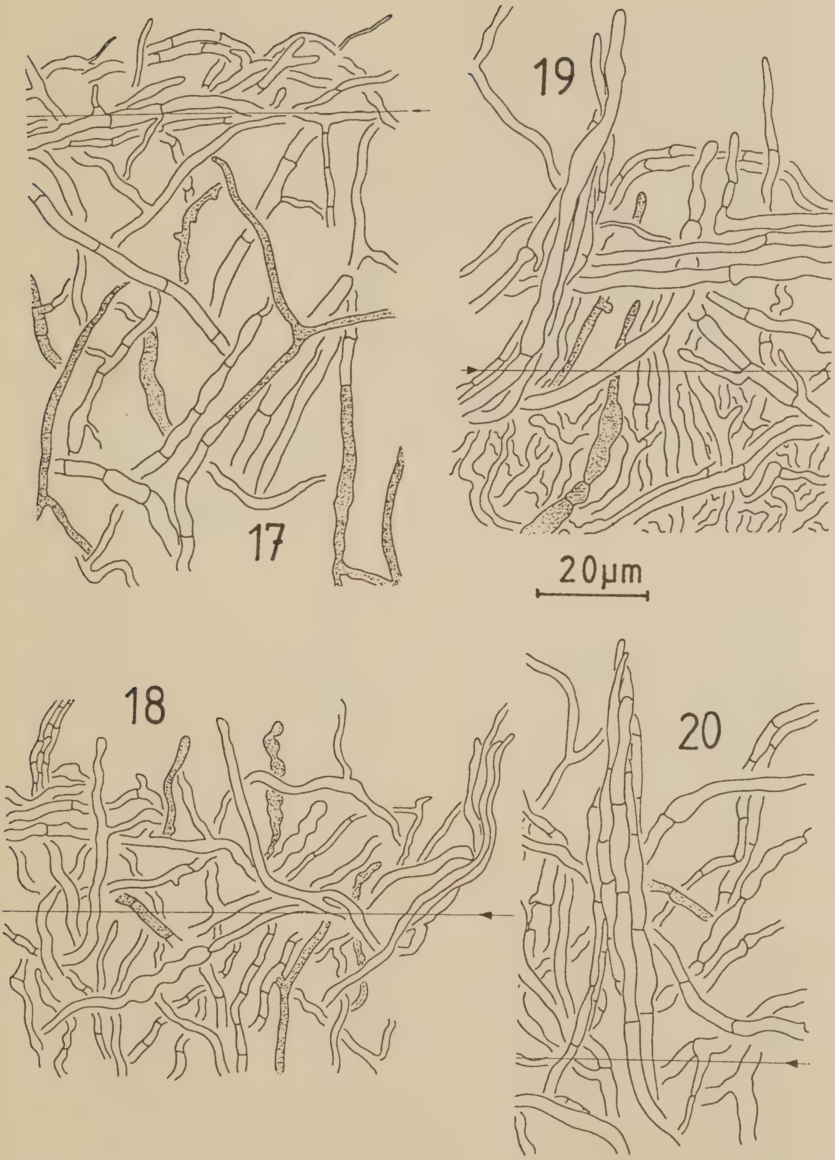


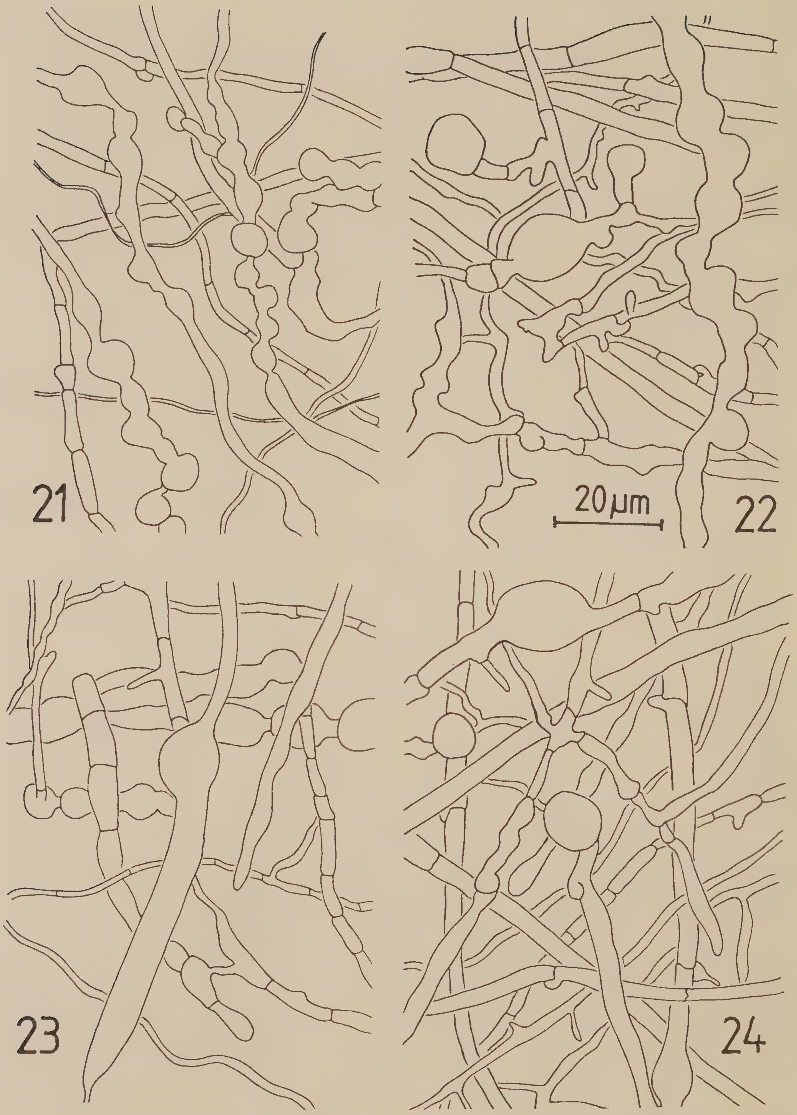
Fig.9: Mycena cinerella (TR 169). - Figures 10-11: Mycena epipterygia. Fig.10: TR 170 with swollen clamps. Fig. 11: TR 178. - Fig.12: Mycena galericulata (TR 151) with hyphal swellings



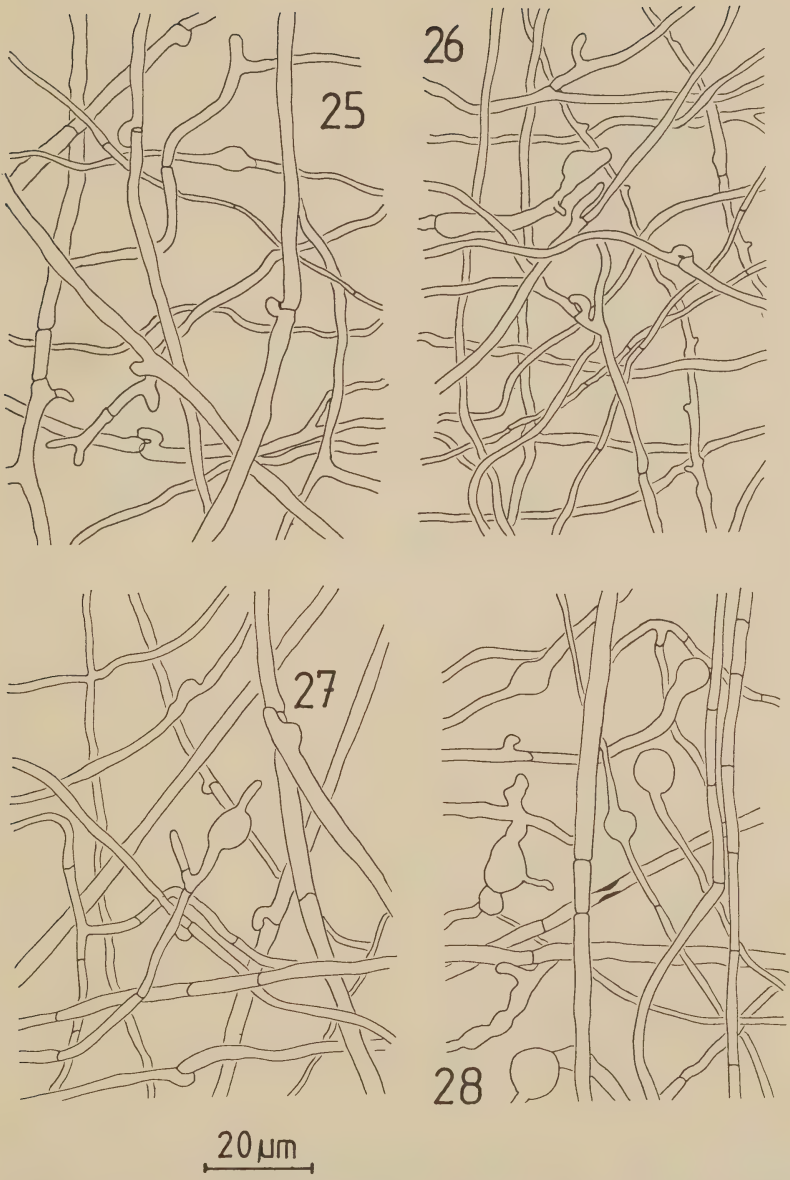
Figures 13-16: Mycena galericulata. Fig.13: Hyphal strand (TR 151). Fig.14: TR 967. Fig.15: Some hyphae with slight thickenings of cell wall (TR 966). Fig.16: Longitudinal section through colony margin (TR 966). Arrow indicates agar surface.



Figures 17-20: Mycena galericulata (TR 966), longitudinal sections. Arrow indicates agar surface. Fig.17-18 section 10 mm from center of colony. Fig.19-20: center of colony.



Figures 21-23: Mycena galopus with hyphal swellings and moniliform hyphae. Fig.21: TR 964. Fig.22: TR 134. Fig.23: TR 975. - Fig.24: Mycena haematopus with hyphal swellings (TR 37).


25
26
27
28
20 µm

Figures 25-28: Mycena maculata. Fig.25: TR 182. Fig.26: TR 188. Fig.27: TR 189. Fig.28: TR 190 with hyphal swellings

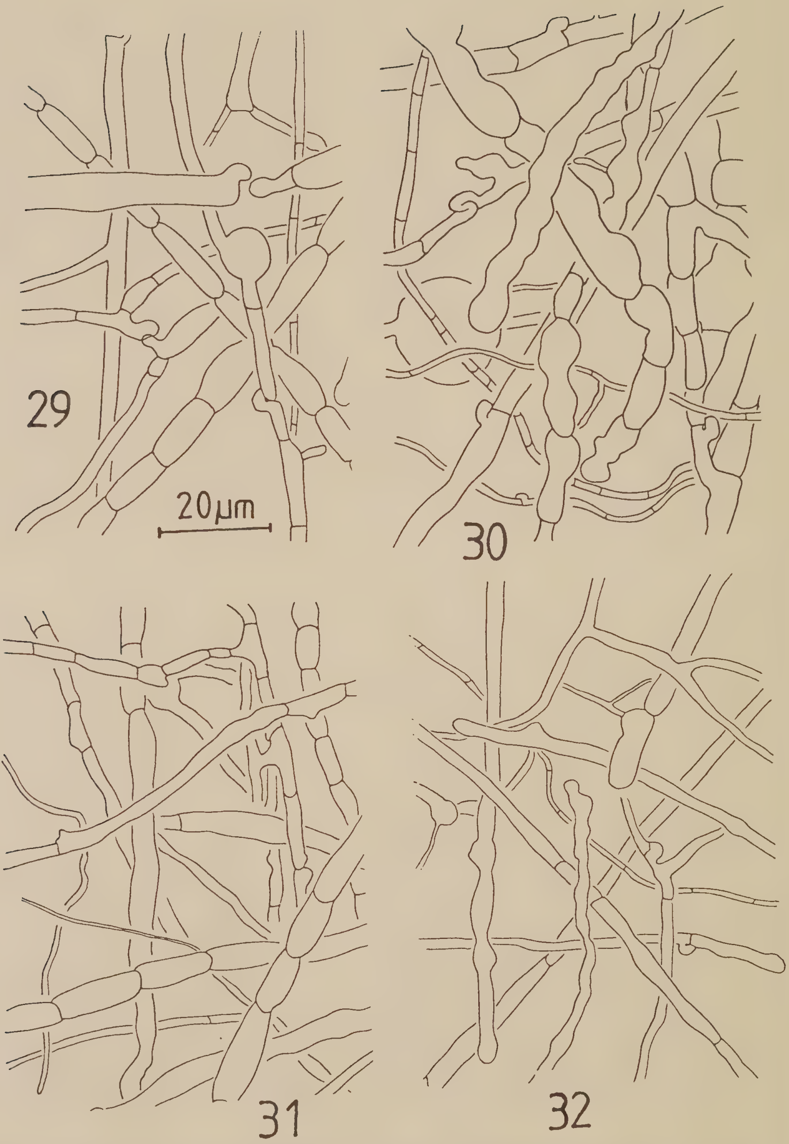

29
20µm
30
31
32

Figure 29-32: Mycena metata. Hyphal swellings in fig.29 and 30. Fig.29: TR 90. Fig.30: TR 115. Fig.31: TR 138. Fig.32: TR 139

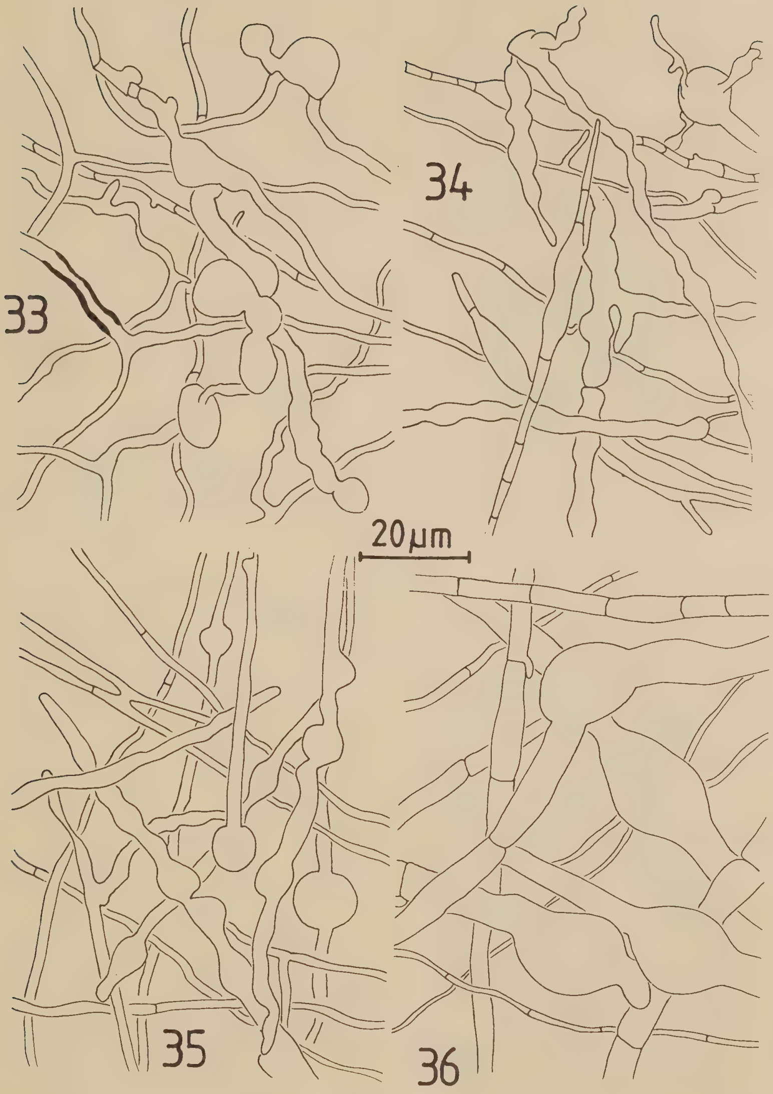
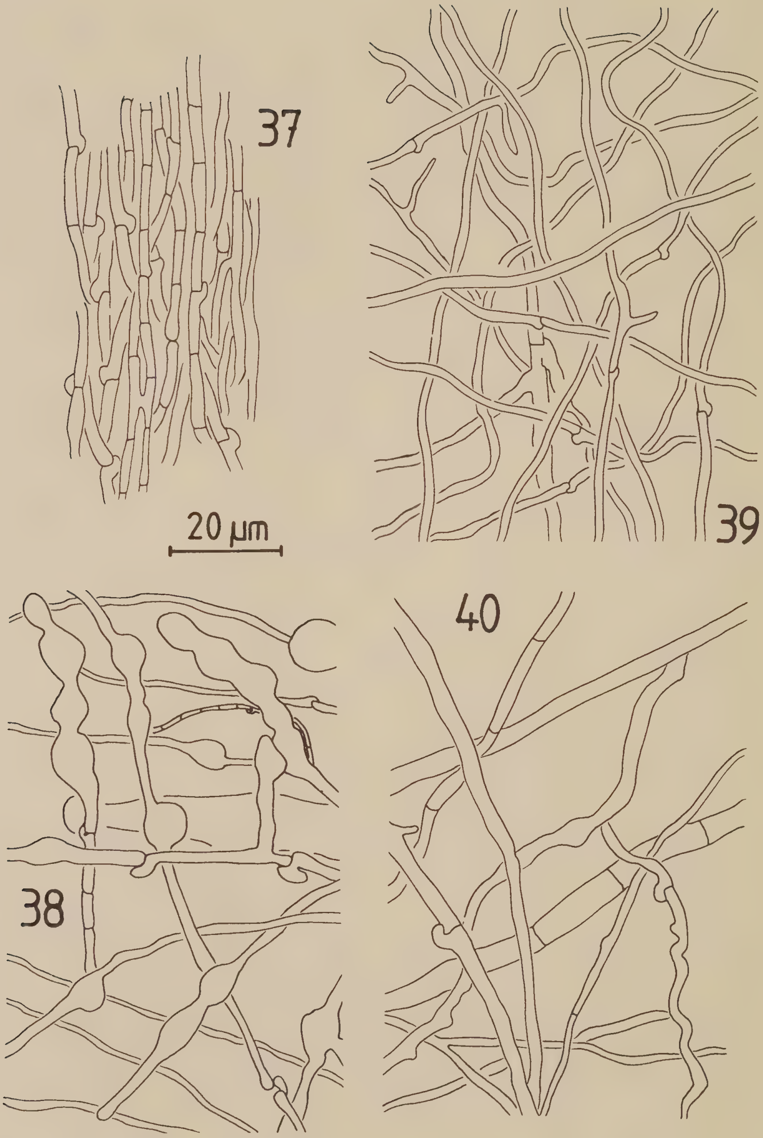


Figure 33: Mycena polygramma (TR 185) with moniliform hyphae; some hyphae with thickened cell wall.- Figures 34-35: Mycena pura with hyphal swellings. Fig.34: TR 136. Fig.35: TR 162. - Fig.36: Mycena rorida (TR 968) with large hyphal swellings



Figures 37-38: Mycena rosea (TR 969). Fig.37: hyphal strand. Fig.38: moniliform hyphae. - Fig. 39: Mycena rosella (TR 963). - Fig.40: Mycena rubromarginata (TR 752)

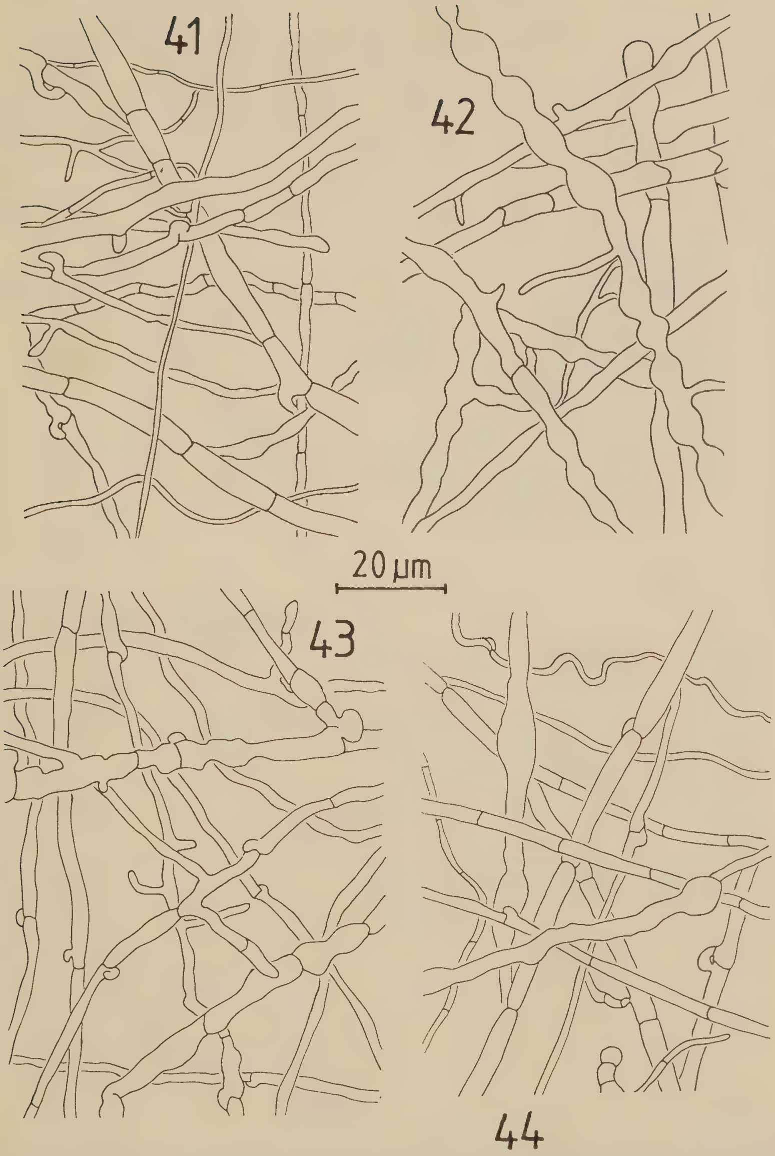


Fig.41: Mycena rubromarginata (TR 970) - Figure 42: Mycena sanguinolenta (TR 974) with moniliform hyphae. - Figures 43-44: Mycena stylobates. Fig.43: TR 971. Fig.44: TR 972

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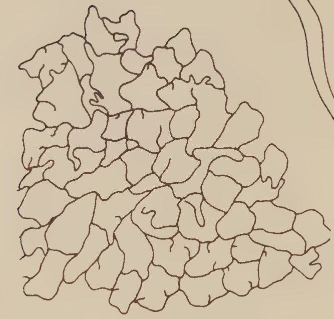

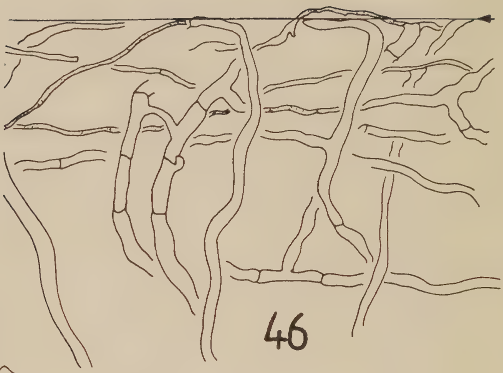

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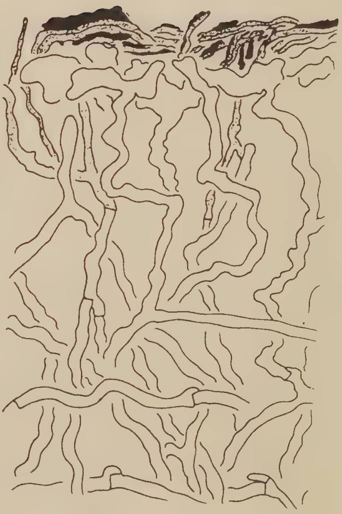
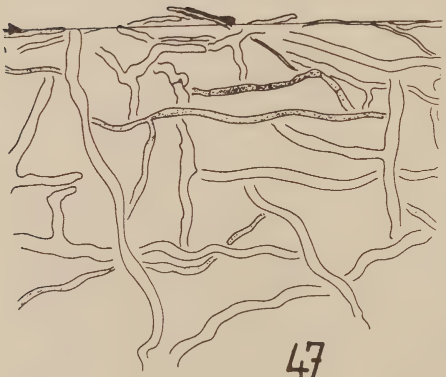
48





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Figures 45-48: Mycena stylobates (TR 972). Fig.45: epidermoid surface view. Figures 46-48: Longitudinal sections. Arrow indicates agar surface. Figures 46,47: margin of colony. Figure 48: center of colony with lobed hyphae and exudates.

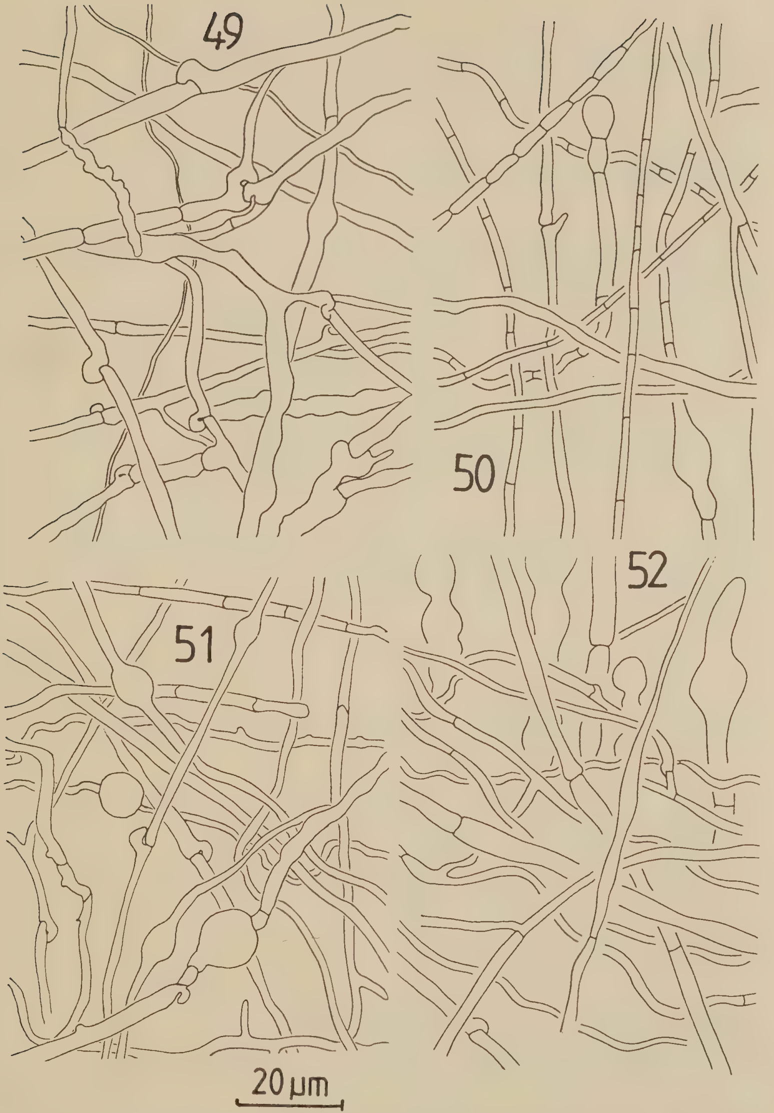

Fig.49: Mycena viridimarginata (TR 973): clamps sometimes slightly swollen. - Fig.50: Mycena vulgaris (TR 116). - Fig.51: Mycena zephirus (TR 59) with hyphal swellings. - Fig.52: Rickenella fibula (TR 965) with hyphal swellings

DISCUSSION

In most cases the characteristics examined here appear to be constant and could be reproduced after reinoculation. Thus the color of the cultures proved to be a valuable feature which in some cases leads to immediate recognition of the species involved. The yellow cultures of Mycena rubromarginata und the blue cultures of Mycena amicta can be distinguished from all the other species at first sight.

Another important character is the brown diffusion zone in malt agar caused by the cultures of Mycena rosella and M. maculata only two or three days after inoculation. Yen (1949) described the same feature for Mycena maculata.

Regarding the growth of the cultures two basic types could be discerned: the first one could be found in most of the cultures and is characterized by a steady growth in radial direction until the rim of the petri dish is reached. The second type was rare and could be observed in cultures of Mycena acicula and Rickenella fibula. It is characterized by colonies which vault over the agar surface but cease to grow in radial direction after having reached a certain diameter. Apart from the presence of clamp connections and the lack of resinous incrustations in cultures of Rickenella fibula it was impossible to distinguish cultures of Mycena acicula and Rickenella fibula, thus supporting the view presented by Kühner (1938, 1980) of a close relationship of these two species.

A specific radish-like smell characterized the cultures of Mycena rosea but wasn't found in any other species. Cultures with a distinct smell were also found by Miller et al.(1983) and Semerdzieva (1966) in the genera Amanita, Piloderma, Pleurotus, Rhizopogon, Scleroderma and Suillus and by Nobles (1965) in several species of Aphyllophorales.

All the strains had the ability to produce extracellular oxidases which was made visible by transferring plugs onto tannic acid agar. A brown diffusion zone could be observed in all species but these results should be interpreted carefully with Mycena rosella and M. maculata because these species also stain malt agar dark brown. According to Miller (1971) most of the species in the Tricholomataceae have extracellular oxidases.

The occurrence of hyphal swellings could be observed in many species. It was highly obvious in all the strains of Mycena galopus. Similar, though septate stuctures were found in the genus Amanita (Campbell & Peterson 1975, Miller et al. 1983) and in several Aphyllophorales (Nobles 1965). Yen (1949) found hyphal swellings in cultures of Mycena maculata.

The diameter of these hyphal swellings varies within the strains and thus cannot be reliable for delimiting different species. An exception may be Mycena rorida with exceptionally large hyphal swellings (up to 15 µm).

A reproductive function of these structures seems highly improbable because of their variable diameter and in most cases the lack of cell walls separating the swellings. Accordingly they have never been observed breaking off. Hutchison (1989) emphasized that a variety of similar swellings, e.g. in cultures of *Laccaria* and *Strobilomyces* are no conidia and ought to be interpreted with prudence.

Also the diameter of hyphae appears to be too variable to be considered as a reliable feature. Here *Mycena rosella* with most hyphae of an invariable diameter of 1-2 µm may be an exception.

Longitudinal sections have been made from cultures of three selected species, *Mycena acicula*, *M. galericulata* and *M. stylobates*. There is an interesting deviation in the latter species with its vertically growing hyphae broadening on their apices into lobes which constitute an epidermoid surface view. It resembles the textura angularis described by Miller (1971) for *Xeromphalina brunneola*. Agerer et al. (1980) found correlations between characteristics of cultural longitudinal sections and those of the fruitbodies.

The occurrence of hyphal strands growing out from the agar surface has been observed in several cultures but in some cases the strands occurred only after a period of eight weeks or more.

Mycena galericulata was one of the rare cases in which differences between strains of one species could be found. The strain TR 151 showed hyphal swellings and hyphal strands, whereas these two characters didn't occur in the other strains (TR 966 and TR 967). Maybe these deviations refer to infraspecific taxa; similar cases with strain specific deviations have also been described by Campbell & Petersen (1975) for cultures of several *Amanita* species.

In many species of *Mycena* the cultures are luminescent. It was important to observe the cultures steadily from the time of inoculation on because a potential luminescent culture doesn't display this character all the time. Older cultures often lack a luminescence but it can be revived by transferring the culture onto a new petri dish. According to Bühler & Bünning (1965) and Calleja & Reynolds (1970) there is an endogenous rhythm of luminescence in some fungal species.

In regarding to luminescence, there may also be strain specific differences. The cultures of *Mycena galopus* showed a strong luminescence with the exception of one strain without luminescence (TR 134). Bothe (1935) observed differences in the degree of luminescence in both haploid and diploid strains of *Mycena galopus*. Cultures of *Mycena stylobates*, *M.epipterygia* and *M.sanguinolenta* observed here showed no luminescence, but Wassink (1948) described cultures of these species as luminescent. There is also the possibility that some crucial environmental factors contribute to the unpredictability of this feature. According to Goto & Kishi (1968) and Watling (1980) all luciferin reactions depend strongly on a sufficient oxygen supply. Bothe (1935) states that luminescence may also depend on the culture medium used.

It is not yet clear how widespread fungal luminescence occurs in the agarics. Luminescence of fruitbodies has been described from the following genera: Armillariella, Flammulina, Mycena, Panellus, Dictyopanus, Omphalotus and Lampteromyces (Corner 1950, Corner 1953, Foerster et al. 1965, Singer 1986). A luminescent fruitbody, however, does not necessarily mean that the species has luminescent mycelium; according to Singer (1986) the mycelium of Omphalotus olearius is not luminescent.

For taxonomical purposes it would be useful to evaluate this character not only in cultures of Mycena but also in related genera. Following the taxonomy applied by Maas Geesteranus (1980b) luminescence may serve to confirm certain relationships. The example of luminescence in Mycena rosea and Mycena pura in the section Calodontes (Fr. ex Berk.) Quel. and of Mycena galopus and Mycena haematopus in the section Lactipedes (Fr.)Quel. shows there may be taxonomic implications. One must also take into consideration that the luminescence of fungal cultures is an elusive character which, in some cases, is not present throughout the lifetime of a colony.

Acknowledgements

The authors wish to thank Prof. Dr. Orson Miller, Virginia Polytechnic Institute and State University for reviewing the manuscript and improving the English text.
Dr. Kost, Tübingen, is acknowledged for reviewing the article.

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MYCOTAXON

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A NEW *DIPLOSCHISTES* SPECIES (LICHENIZED ASCOMYCETES, THELOTREMATACEAE) FROM INDIA

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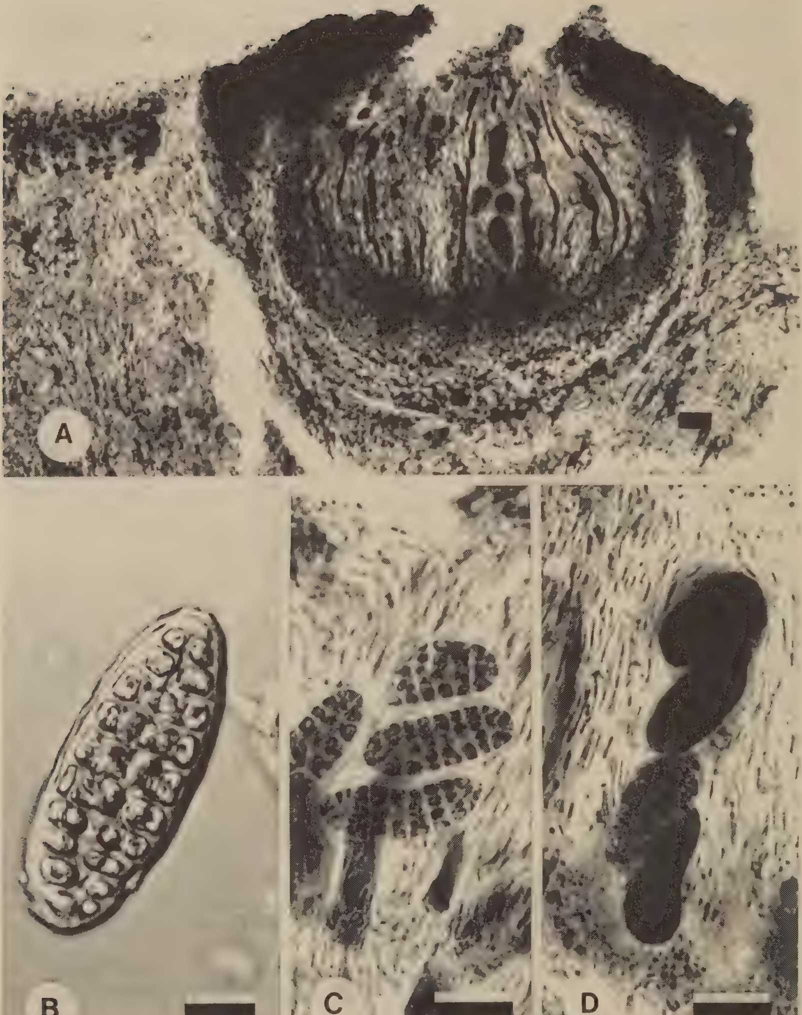
ABSTRACT: *Diploschistes megalosporus* nom.nov. is reported from India. Its relationships to *Diploschistes actinostomus* and *D. caesioplumbeus* are discussed.

During the revision of the lichenized ascomycete genus *Thelenella* (syn. *Microglaena* s.str.) by MAYRHOFER (1987) it appeared that one species described as *Microglaena areolata* actually belonged to the genus *Diploschistes*. A simple combination is not possible because this epithet is already in use within *Diploschistes*. Therefore we propose a nomen novum:

Diploschistes megalosporus LUMBSCH & MAYRHOFER nom.nov.

BASIONYM: *Microglaena areolata* AWASTHI & K. P. SINGH, *Norw. J. Bot. 19* : 239 (1972). - non *Diploschistes areolatus* (NYL.) ZAHLBRUCKNER, *Hedwigia 31*: 34 (1892). = *Urceolaria areolata* NYLANDER, *Ann. Sci. Nat. Bot., Ser. 4, 11* : 220 (1859).

TYPE: *India* : South India, Palni Hills, Perumalmalai area, near the Perumal peak, 6000-7800 ft, 17.xii.1970, *K. P. SINGH 70.1091* (LWU - holotype)



Figures A - D. *Diploschistes megalosporus*. A, immersed ascoma, scale = 10 µm; B, muriform ascospore, scale = 10 µm; C, ascospores before treatment with I, scale = 20 µm; D, ascospores after treatment with I, scale = 20 µm.

Thallus crustose, epilithic, effuse, smooth, glossy, pale grey to bluish grey, rimose-areolate. Photobiont *Trebouxia* s.l. *Chemistry* : K+ yellow to red, C+ red, PD-; TLC: diploschistesic and lecanoric acids. *Ascomata* (fig. A) immersed, perithecioid, to 0,6 mm diam. Excipulum proprium black, pseudoparenchymatous, to 75 µm thick; hymenium 140-180 µm, hyaline; hypothecium 10-15 µm, hyaline; paraphyses 1-2 µm thick, simple, loose. Asci subclavate, 130-170 x 15-35 µm, 4-6 spored; ascospores broadly ellipsoid, hyaline, muriform (fig. B+C) with 6-12 transvers and 2-5 longitudinal divisions, 45-65 x 15-25 µm, I+blue (fig. D). *Conidiomata* not seen.

Diploschistes megalosporus is characterized by its large I+blue ascospores. The species is morphologically similar to both *D. actinostomus* and *D. caesioplumbeus*. However, the ascospores of these latter species are clearly smaller and do not show a I+blue reaction. This reaction is characteristic for several species of *Diploschistes*, (e.g. *D. diploschistoides* (VAIN.) SALISBURY) but is unknown amongst the holarctic species (LUMBSCH 1989: 146).

Distribution : At present the new species is only known from the type locality in the mountains of Southern India.

ACKNOWLEDGEMENTS

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MYCOTAXON

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THE GENUS *LALARIA* GEN. NOV.: TAPHRINALES ANAMORPHOSUM

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SUMMARY

The new anamorphic genus *Lalaria* Moore is described for the yeast-phase anamorphs of the Taphrinales. Twenty three species, for which cultures are available, are described in the genus.

I. INTRODUCTION

The order Taphrinales Gaüman comprises three families (Reddy & Kramer, 1975; Kramer, 1987): the monotypic Taphrinaceae (*Taphrina* Fr. - 95 spp.; Mix, 1949), the Protomycetaceae (*Protomyces* Unger - 10+ spp., *Protomycopsis* Magnus - 5 spp., *Taphridium* Lagerh. & Juel - 2 spp., *Volkartia* Maire - 1 sp.), and the monotypic Mixiaceae (*Mixia* Kramer - 1 sp.). These fungi are dimorphic. The diplophase is infective and may be either dikaryotic or diploid. The haplophase is saprobic and in culture produces slow growing, yeast-like colonies that are pinkish to red in color.

II. THE TELEOMORPH PHASE

The species of *Taphrina* are classified entirely by teleomorph characters: ascus morphology, location of the mycelium within the host tissue, histological effects on the host, and the host species. There are, however, many examples where morphological criteria overlap and host specificity is inconsistent. These fungi are all highly specialized plant parasites of limited host range and are found naturally only on their respective host plants where they cause malformations of the tissues attacked, producing such disease symptoms as leaf curl, puckering, pockets, blisters, and witches' broom.

Ascospores are formed only in nature and bud readily, either within the ascus or after spore discharge. There is reason to believe (Mix 1935) that propagation by budding in the anamorphic phase may continue indefinitely, the cells surviving in this fashion on various plant surfaces and probably also in the soil.

Several hosts have species complexes, particularly the 16 isolates of *T. caerulescens* on *Quercus* that comprise 14 assimilation profiles (anamorph species). There are also three isolates identified as *T. betulina* Rostr. that were originally separate species of *Taphrina* (*T. betulina* and *T. lapponica* Juel on *Betula intermedia* Thomas and *T. turgida* on *B. pendula* Roth). Their original classification is supported by their distinct assimilation profiles.

III. THE ANAMORPH PHASE

When it is not known that a culture has originated from a *Taphrina* ascospore it is sometimes difficult to establish whether it is a *Taphrina* anamorph or a species of *Rhodotorula* or *Cryptococcus*. Kreger-van Rij (1984) distinguished *Taphrina* anamorphs from *Rhodotorula* spp. on the basis that the former produce starch and from *Cryptococcus* spp. on the basis that the latter can utilize inositol.

These yeasts are undefined. Three particular reasons come to mind. Except for Mix (1953; 1954) and Verona & Rambelli (1962a, b), little serious attention has been given to their systematic characterization, to providing them with standard yeast descriptions. A second reason is that despite their importance in plant pathology, this discipline has ignored them. A third and most important reason is that these forms have no corporate identity, an anamorph name. For want of this they are ecologically invisible. Mix (1935) said that they should be common on plant surfaces and probably in the soil, yet they get no mention in this literature (e.g., Carmo-Sousa, 1969; Last & Price, 1969; Preece & Dickinson, 1971; Phaff & Starmer, 1987).

Mix (1954) examined 74 isolates, representing 26 species and 55 host forms for their ability to use 32 different carbon compounds. His culture medium contained, per liter distilled water: 1.1 g NH_4Cl, 2.75 g KH_2PO_4, 1.25 g $MgSO_4.7H_2O$, and 1 g carbon compound; 4.5 ml of the respective solutions were dispensed into 15 X 125 mm tubes. The tubes were incubated for 21 days at room temperature (20°-24° C.) at which time a visual determination of turbidity was scored as either no growth, slight but definite growth (w), or moderate to good growth. All isolates utilized glucose, sucrose, maltose, melezitose, trehalose, dextrin, inulin, and pectin; none of them utilized lactose, rhamnose, inositol, or i-erythritol. All but the two isolates of *T. polystichi* used xylose and all but the iso-lates of *T. polystichi* and *T. nana* used succinic acid. The isolates exhibited various responses to 18 compounds: galactose, levulose, mannose, raffinose, cellobiose, L-arabinose, melibiose, L-sorbose, D-ribose, adonitol (ribitol), dulcitol (galactitol), mannitol, D-sorbitol, ethanol, glycerol, salicin, soluble starch, and citric acid. In an earlier paper Mix (1953) examined the ability of these isolates to utilize nitrogen compounds. His culture medium contained, per liter distilled water: 2.75 g KH_2PO_4, 1.25 g $MgSO_4.7H_2O$, 10 g glucose and the particular inorganic nitrogen source at a nitrogen equivalent concentration of 2 g KNO_3 l^{-1}. Tubes were prepared and cultured as above and growth was given one of five scores: 0, trace, +, ++, or +++. The results showed that all isolates could utilize urea and asparagine, that none could utilize ammonium acetate, and that most could utilize ammonium chloride and ammonium nitrate.

More recently, Yamada et al. (1983; 1987) have shown ubiquinone values of Co-Q 10 for all species of the order so far examined. These observations, with similar results, have been extended by Moore & Flinn (report in preparation).

What is proposed is a taxonomic holding area (like *Candida* once was and to some extent still is) to bring all taphrinealean anamorphs together. From this 'lumping' later studies can determine how these forms should be assorted into well-defined species, additional genera, and higher taxa. A new anamorphic genus is therefore proposed for these forms and diagnoses are provided for 23 new species for which isolates are available in culture collections.

IV. LATIN DIAGNOSES

Lalaria Moore gen. nov. Colonia carotenoidis tinctis, blastans variabilis. Assimulosis facies obliqua in tabula nutrimenta infra:

Glucose	+	Asparagine	+	L-Rhamnose	-
Maltose	+	Form starch-like compounds	+	Erythritol	-
Sucrose	+			Inositol	-
Trehalose	+	Dextrin	+	Ammon. acetate	-
Melezitose	+	Pectin	+	Thiamine req.	-
Inulin	+	Gluc. ferment.	-	Temp. max.	28°C
Urea	+	Lactose	-	Co-Q	10

Species typicus: *Lalaria populina* Moore.
Teleomorphosis: Taphrinales Gaümann (sensu lat.).
Etym. La'laria, the name of a pebble beach on the Greek island of Skiathos known for its smooth, uniform-sized stones; in allusion to the yeast-like morphology.

1. **Lalaria americana** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-arabinose	+	D-glucitol	+
L-sorbose	-	D-ribose	-	Salicin	-
Cellobiose	-	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	-	Citric acid	+
Raffinose	+	Ribitol	w	Nitrate	-
Soluble starch	-	Galactitol	w		
D-xylose	+	D-mannitol	+		

Teleomorphis: *Taphrina americana* Mix.
Hostis: *Betula fontinalis* Sarg.
Originis: Mix (1954), no. 1 (CBS 331.55).

2. **Lalaria caerulescens** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-arabinose	-	D-glucitol	+
L-sorbose	-	D-ribose	w	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	-
Raffinose	-	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-mannitol	+		

Teleomorphis: *Taphrina caerulescens* (Mont. & Desm.) Tulasne.
Hostis: *Quercus alba* L.
Originis: Mix (1954), no. 5 (CBS 351.35).

3. **Lalaria carnea** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-	Co-Q (orig. obs.)	10
D-xylose	+	D-Mannitol	w		

Teleomorphosis: *Taphrina carnea* Johans.
Hostis: *Betula intermedia* Thomas.
Originis: Mix (1954), no. 21 (CBS 332.55).

4. **Lalaria cerasi** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	+	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	-	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-	Co-Q (Yamada et al. 1983)	10
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina cerasi* (Fkl.) Sadeb.
Hostis: *Prunus avium* L.
Originis: Mix (1954), nos. 22, 23, 24 (CBS 275.28).

5. **Lalaria coccinea** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	+	D-Glucitol	+
L-sorbose	w	D-Ribose	+	Salicin	+
Cellobiose	+	Ethanol	+	Succinic acid	+
Melibiose	-	Glycerol	+	Citric	+
Raffinose	w	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	+		
D-xylose	+	D-Mannitol	+		

Teleomorphis: *Taphrina caerulescens* (Mont. & Desm.) Tulasne.
Hostis: *Quercus coccinea* Muench.
Originis: Mix (1954), no. 7 (CBS 333.55).

6. **Lalaria communis** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	+

L-sorbose	+	D-Ribose	+	Salicin	-
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina communis* (Sadeb.) Giesenhag.
Hostis: *Prunus americana* Marsh.
Originis: Mix (1954), nos. 27, 28, 29 (CBS 352.35).

7. **Lalaria confusa** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	+
L-sorbose	-	D-Ribose	+	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	+	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	+	Galactitol	+		
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina confusa* (Atk.) Giesenhag.
Hostis: *Prunus virginiana* L.; *P. virginiana* var. *demissa* Torr.
Originis: Mix (1954), no. 39 (CBS 375.39).

8. **Lalaria dearnessii** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	+	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina dearnessii* Jenkins.
Hostis: *Acer rubrum* L.
Originis: Mix (1954), no. 40 (CBS 334.55).

9. **Lalaria deformans** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	+	D-Ribose	-	Salicin	w
Cellobiose	-	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	-	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-	Co-Q (Yamada et al. 1987)	10
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina deformans* (Berk.) Tul.
Hostis: *Prunus communis* L.; *P. persica* L.
Originis: Mix (1954), nos. 41, 42 (CBS 356.35).

10. **Lalaria farlowii** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	w	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina farlowii* Sadeb.
Hostis: *Prunus serotina* Thrh.
Originis: Mix (1954), nos. 45, 46 (CBS 376.39).

11. **Lalaria flavorubra** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	-	D-Ribose	w	Salicin	w
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	w	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina flavorubra* Ray.
Hostis: *Prunus besseyi* Bailey.
Originis: Mix (1954), nos. 47, 48 (CBS 377.39).

12. **Lalaria johansonii** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	-	Ribitol	-	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina johansonii* Sadeb.
Hostis: *Populus tremuloides* Michx.
Originis: Mix (1954), nos. 49, 50 (CBS 378.39).

13. **Lalaria letifera** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	w
L-sorbose	-	D-Ribose	-	Salicin	w
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	+	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina letifera* (Pk.) Sacc.
Hostis: *Acer spicatum* Lam.
Originis: Mix (1954), no. 51 (CBS 335.55).

14. **Lalaria nana** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	w
L-sorbose	-	D-Ribose	w	Salicin	-
Cellobiose	-	Ethanol	-	Succinic acid	-

Melibiose	-	Glycerol	-	Citric acid	+
Raffinose	+	Ribitol	w	Nitrate	+
Soluble starch	+	Galactitol	-		
D-xylose	+	D-Mannitol	-		

Teleomorphosis: *Taphrina nana* Johans.
Hostis: *Betula nana* L.
Originis: Mix (1954), no. 52 (CBS 336.55).

15. **Lalaria polystichi** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	-
L-sorbose	-	D-Ribose	-	Salicin	-
Cellobiose	-	Ethanol	-	Succinic acid	-
Melibiose	-	Glycerol	-	Citric acid	-
Raffinose	-	Ribitol	-	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	-	D-Mannitol	+		

Teleomorphosis: *Taphrina polystichi* Mix.
Hostis: *Polystichum acrostichoides* (Michx.) Schott.
Originis: Mix (1954), nos. 53, 54 (CBS 379.39).

16. **Lalaria populi-salicis** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	-
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	-	Citric acid	-
Raffinose	-	Ribitol	-	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina populi-salicis* Mix.
Hostis: *Populus trichocarpa* Torr. et Gray.
Originis: Mix (1954), no. 58 (CBS 419.54).

17. **Lalaria populina** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	w	Citric acid	-
Raffinose	-	Ribitol	-	Nitrate	+
Soluble starch	-	Galactitol	-	Co-Q (orig. obs.)	10
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina populina* Fr.
Hostis: *Populus nigra* L.
Originis: Mix (1954), nos. 55, 56 (CBS 337.55).

18. **Lalaria pruni-subcordatae** Moore, sp.nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	w
L-sorbose	-	D-Ribose	+	Salicin	+
Cellobiose	+	Ethanol	+	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	-
Raffinose	+	Ribitol	w	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina pruni-subcordatae* (Zeller) Mix.
Hostis: *Prunus subcordata* Benth.
Originis: Mix (1954), no. 62 (CBS 381.39).

19. **Lalaria purpurascens** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	-	D-Glucitol	+
L-sorbose	+	D-Ribose	-	Salicin	+
Cellobiose	-	Ethanol	-	Succinic acid	+
Melibiose	+	Glycerol	+	Citric acid	+

Raffinose	+	Ribitol	-	Nitrate	-
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina purpurascens* Robins.
Hostis: *Rhus copallina* L.
Originis: Mix (1954), no. 63 (CBS 338.55).

20. **Lalaria robinsoniana** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	+	D-Glucitol	+
L-sorbose	-	D-Ribose	+	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	+	Glycerol	+	Citric acid	+
Raffinose	+	Ribitol	-	Nitrate	+
Soluble starch	+	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina robinsoniana* Giesenhag.
Hostis: *Alnus rugosa* (Du Roi) Spreng; *A. serrulata* (Ait) Willd.
Originis: Mix (1954), nos. 64, 67, 69 (CBS 382.39; CBS 383.39).

21. **Lalaria tosquinetii** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	-	L-Arabinose	+	D-Glucitol	+
L-sorbose	-	D-Ribose	-	Salicin	+
Cellobiose	-	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	-	Citric acid	-
Raffinose	-	Ribitol	-	Nitrate	+
Soluble starch	-	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina tosquinetii* (Westend.) Tulasne.
Hostis: *Alnus glutinosa* Gaertn.
Originis: Mix (1954), nos. 74, 75 (CBS 276.28).

22. **Lalaria ulmi** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	w
L-sorbose	w	D-Ribose	-	Salicin	+
Cellobiose	+	Ethanol	+	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	+
Raffinose	-	Ribitol	+	Nitrate	-
Soluble starch	+	Galactitol	w		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina ulmi* (Fkl.) Johans.
Hostis: *Ulmus rubra* Muhl.
Originis: Mix (1954), nos. 77, 78 (CBS 420.54).

23. **Lalaria virginica** Moore, sp. nov. Assimulosis facies obliqua in tabula nutrimenta infra:

Galactose	+	L-Arabinose	+	D-Glucitol	+
L-sorbose	+	D-Ribose	+	Salicin	+
Cellobiose	+	Ethanol	-	Succinic acid	+
Melibiose	-	Glycerol	+	Citric acid	-
Raffinose	-	Ribitol	+	Nitrate	+
Soluble starch	+	Galactitol	-		
D-xylose	+	D-Mannitol	+		

Teleomorphosis: *Taphrina virginica* Sadeb.
Hostis: *Ostrya virginiana* (Mill.) K. Koch.
Originis: Mix (1954), no. 79 (CBS 340.55).

KEY TO THE SPECIES OF *LALARIA*

1 a. L-Arabinose + ... 2
b. L-Arabinose - 13
2(1) a. Soluble starch + ... 3
b. Soluble starch - 7
3(2) a. Melibiose + ... 4
b. Melibiose - 5
4(3) a. Galactose + ... *L. confusa*
b. Galactose - . . . . *L. robinsoniana*
5(3) a. KNO_3 + ... 6
b. KNO_3 - . . . . *L. ulmi*
6(5) a. L-Sorbose + ... *L. virginica*
b. L-Sorbose - . . . . *L. nana*
7(2) a. Melibiose + ... *L. dearnessii*
b. Melibiose - 8
8(7) a. Galactose + ... 9
b. Galactose - 12
9(8) a. D-Ribose + ... 10
b. D-Ribose - 11
10(9) a. Sorbose + ... *L. communis*
b. Sorbose - . . . . . . *L. pruni-subcordatae*
11(9) a. Cellobiose + ... *L. carnea*
b. Cellobiose - . . . . *L. americana*
12(8) a. Cellobiose + ... *L. coccinea*
b. Cellobiose - . . . . *L. tosquinetii*
13(1) a. Raffinose + ... 14
b. Raffinose - 18
14(13)a. Sorbose + ... 15
b. Sorbose - 16
15(14)a. Cellobiose + ... *L. cerasi*
b. Cellobiose - . . . . *L. purpurascens*
16(14)a. D-Mannitol + ... *L. letifera*
b. D-Mannitol - 17
17(16)a. Melibiose + ... *L. farlowii*
b. Melibiose - . . . . *L. flavorubra*
18(13)a. Citric acid + ... 19
b. Citric acid - 20
19(18)a. Cellobiose + ... *L. johansonii*
b. Cellobiose - . . . . *L. deformans*
20(18)a. Glycerol + ... 21
b. Glycerol - 22

21(20)a. Ribitol + ... *L. caerulescens*
b. Ribotol - . . . . *L. populina*
22(20)a. D-Ribose + ... *L. populi-salicis*
b. D-Ribose - . . . . *L. polystichi*

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AN ARTIFICIAL KEY TO THE GENERA OF THE PARMELIACEAE (LICHENES, ASCOMYCOTINA)

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INTRODUCTION

During the last forty years the lichen family Parmeliaceae has been carefully studied with the aid of modern techniques for the identification of chemical constituents (microrecrystallization, TLC and HPLC) and for detection of microscopic features (especially SEM). The process of taxonomic revision resulted in the subdivision of *Parmelia* s. lat. on the basis of chemical, morphological, anatomical and geographical characters. Thus, numerous new generic names, corresponding to newly delimited taxa were published. A similar fragmentation has also begun in *Cetraria* s. lat. (2, 4) but a more complete revision of some cetrarioid groups of species is still needed.

Although the knowledge on the parmeliaceous species is well advanced and the new generic delimitations are recognized by many lichenologists, a key to these genera has not yet been published. During the author's work on the parmeliaceous flora of Argentina, it became evident that a key to genera of Parmeliaceae would be an useful tool, especially to those begining taxonomic or floristic studies. The purpose of this paper is to propose such a key. It also summarizes the literature upon which it is based: the user will easily locate the main papers refered to each genus, searching in "Literature cited" the titles which correspond to the numbers under each genus name in the key.

For general morphological and chemical definitions and concepts the user must refer to Hale (27, 29) but for more precision and information it is necessary to refer to the specific papers.

Hale's delimitation of the family (29) has been followed here, but new names published later have also been included. Pseudevernia (16) and Brodoa (13) were left out because their affinity to Parmeliaceae is under evaluation (Hale, pers. comm.).

KEY TO THE MAIN ARTIFICIAL GROUPS

1- Upper cortex with usnic acid, generally K- (K+ yellow when usnic acid is accompanied by atranorin). Thallus mostly pale to dark yellowish-green..........**KEY A**

1- Upper cortex without usnic acid.............2

  2- Upper cortex with atranorin (then K+ yellow); rarely this cortical substance is lacking or is replaced by lichexanthone (then the thallus surface is K-). Thallus generally grey or greenish-grey, sometimes with a brown tinge or frankly brown, but in this case the upper cortex is K+ yellow (with atranorin).. ....**KEY B**

  2- Upper cortex without atranorin (K-) but with brown pigments present. Thallus light to dark brown, with a yellowish, olive, reddish, greenish or blackish tinge...................................**KEY C**

KEY A

Thallus light or dark yellowish-green,greenish-yellow or yellow. Upper cortex K- (with usnic acid). Sometimes the usnic acid is accompanied by atranorin (then the upper cortex is slight or heavily K+ yellow, in relation to the ammount of atranorin present).

1- Th. subfruticose, ascending, with nephromoid apothecia (marginal on the lower side)...............**NEPHROMOPSIS**
(e.g.Cetraria pallidula; 12,46,39)

1- Th. small, very tightly adnate to rocks, subcrustose-areolate at the centre, lobate at the margins. Lobes narrow (up to 1.2 mm broad). Lower side without true cylindrical rhizines but with tomentum-like rhizoids or irregular, flattened, lamella-like, loose aggregations of rhizoids; apothecia laminal on the upper surface...**KAROOWIA**
(36)

1- Th. foliose, leathery, umbilicate and saxicolous, with a thick, strongly effigurate-maculate upper cortex.

Lobes 5-20 mm wide. Lower side with true rhizines; apothecia laminal on the upper surface....**XANTHOMACULINA**
(two African species,31)

1- Th. foliose, leathery, free-growing on soil, forming blackish tubular sticks as the lobes roll upwards. Lobes 2-5 mm wide when convolute, 10-15 mm wide when wet and expanded. Upper surface thick, strongly effigurate maculate. Lower side with true rhizines; apothecia not known..............................**XANTHOMACULINA**
(X.convoluta,Africa (Namibia),31)

1- Th. foliose, appressed, tightly or loosely adnate, corticolous, saxicolous or terricolous. Upper surface maculate or not. Lower side bare or with true rhizines. Apothecia generally laminal on the upper surface, infrequently marginal....................................2

2- Th. with pseudocyphellae...........................3

2- Th. without pseudocyphellae(+).....................6

3- Th. with laminal pseudocyphellae on the lower side...... ....**CETRARIOPSIS**
(45;=Ahtia,46)

3- Th. with laminal pseudocyphellae on the upper side.....4

4- Apothecia nephromoid, marginal, being at maturity perpendicular to the thallus............**CETRELIOPSIS**
(46)

4- Apothecia not nephromoid, laminal on the upper surface...5

5- Th. leathery, saxicolous, upper surface notoriously effigurate-maculate; medulla K+ yellow turning red (salazinic acid)..............................**NAMAKWA**
(35)

5- Th. not leathery, corticolous, terricolous or saxicolous. Upper cortex not maculate. Medulla K-, C+ red (lecanoric acid).....................**FLAVOPUNCTELIA**(++)
(30,42,28,14)

6- Lower side velvety (with small papillae); upper cortex with atranorin and usnic acid as major chem-

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(+) If the material has no pseudocyphellae but the lobes are quite broad (5-8 mm), the lower surface is black with few marginal rhizines, the medulla has lecanoric acid and there are marginal soralia, enter directly in point 5.

(++) One species without pseudocyphellae: F.soredica (28).

ical compounds..7

6- Lower side not velvety but smooth (not papillate), glossy or dull; atranorin absent, present as traces or in large ammounts..............................8

7- Lower side sparsely rhizinate; alectoronic acid in the medulla (Arctic species)..............**ARCTOPARMELIA** (32,37)

7- Lower side erhizinate; without alectoronic acid in the medulla (two species of the Southern Hemisphere in the High Andes)....................(37) **PSILOPARMELIA**

8- Lower side erhizinate................................9

8- Lower side sparsely or densely rhizinate..........10

9- Upper cortex with high ammounts of atranorin besides usnic acid.................................**ASAHINEA** (A.chrysantha,2)

9- Upper cortex without atranorin or only traces, besides usnic acid.............................**XANTHOPARMELIA** (six species,37)

10- Rhizines of the lower side mostly dichotomously branched...........................**HYPOTRACHYNA**(+) (43,21,18)

10- Rhizines mostly not dichotomously branched........11

11- Lobes with carbonized marginal cilia (rhizines,++)..... 12

11- Lobes without carbonized marginal cilia..............13

12- Marginal cilia with inflated base (bulbate cilia). Thallus tightly appressed; lobes sublinear or linear-elongate, 0.3-3 mm wide (Malasia, Asia, Australasia, Philippines)..................**RELICINA** (22,17)

12- Marginal cilia not bulbate (without inflated base). Thallus generally loosely appressed and adnate, with subirregular, subrotund or rotund lobes, (3-) 5-10 (-25) mm broad (extense distribution: tropical, subtropical, temperate)...**PARMOTREMA**(+++) (44,15)

(+) A few species of Xanthoparmelia have also rhizines mostly dichotomously branched and usnic acid (7, page 167).

(++) Carbonized marginal cilia are structures equivalent to marginal rhizines (43, page 13).

(+++) Cortical usnic acid is accompanied by atranorin (44, 15).

13- Th. corticolous..**14**

13- Th. saxicolous...**17**

13- Th. terricolous..........................**XANTHOPARMELIA** (7,17)

14- Th. loosely appressed, frequently loosely adnate; lobes generally broad, (3-) 5-10 (-25) mm wide, subirregular, apically subrotund or rotund; apothecia substipitate to stalked.................**PARMOTREMA** (44,15)

14- Th. appressed to closely appressed, frequently well adnate; lobes narrow or of medium width, less than 5 mm broad; apothecia sessile to substipitate. **15**

15- Lobes irregular or subirregular, 1-5 (-6) mm broad, spores ellipsoid, 15 µm long or longer....**FLAVOPARMELIA**

15- Lobes sublinear or linear elongate, 0.5-3 (-4) mm broad; spores under 8 µm long or about 15 µm long, but in this case they are allantoid (not ellipsoid).........**16**

16- Lobes 2-3 (-4) mm broad. Thallus with laminal, emergent pycnidia and subspherical spores 4-6 µm diam.; conidia bifusiform (+) (one Northamerican species)...................................**ATHIANA** (12)

16- Lobes 1-2 (-3) mm broad. Thallus with marginal rarely laminal, sometimes emergent, pycnidia. Conidia cylindrical to sublageniform (+). Spores ellipsoid, 3-5 X 5-8 µm (a few Asiatic and Australasian species)..............................**RELICINOPSIS** (8,24,20)

16- Lobes 0.5-1 (-1.5) mm broad. Thallus with laminal immersed pycnidia with falcate conidia. Spores reniform or allantoid, about 15 µm long or a little longer (two species of the Northern Hemisphere)..**PARMELIOPSIS** (38,49,48)

17- Lobes narrow to medium, (0.5-) 1-4 (-6) mm broad......**18**

17- Lobes broad, more than 6 mm wide, apically rotund...**PARMOTREMA**(++) (44,15)

18- Th. appressed to tightly appressed, lobes irregular or subirregular, apically rotund or subrotund;

(+) Krog's (42) conidial terminology is frequently used in this paper (sublageniform=fusiform; short filiform= cylindrical or rod-shaped).

(++) e.g. Parmotrema dominicanum.

spores more than 15 µm long.......**FLAVOPARMELIA**(+) (33,24,20)

18- Th. closely to loosely appressed. Lobes plane to convex (with a canaliculate lower surface). Plane-lobed species range from conspersoid (short, broader lobes (3-6 mm wide) with rotund apices) to stenophylloid (elongate, narrow lobes (0.5-3 mm wide); spores less than 15 µm long..**XANTHOPARMELIA**(+) (7,17)

KEY B

Thallus with upper surface pale or dark grey or greenish-grey, generally K+ yellow (presence of atranorin) infrequently K- (absence of atranorin or its replacement by the UV+ substance lichexanthone in some species of Hypotrachyna, 21). Sometimes the thallus has a brown tinge or is frankly chestnut or olive-brown (but the K+ yellow reaction of the surface allows the differentiation from the taxa grouped in **KEY C**). In some cases the grey thallus may have a yellowish tinge (yellow pigments). The th. is foliose, mainly with a postrate habit; the apothecia are mostly laminal on the upper surface although in a few cases they marginal or submarginal.

1- Th. with non carbonized marginal projections or spinules; th. olivaceous or brown (upper cortex K+ yellow,only in one species, K-); apothecia nephromoid...**TUCKERMANNOPSIS** (the Cetraria ciliaris group;46,45,3)

1- Th. with coacervate hyphae (short rhizoids 0.1-0.5 mm long) at the margins. Lobes dichotomously branched...**EVERNIASTRUM** (E.americanum;51,5)

1- Th. without marginal cilia, projections or coacervate hyphae..**2**

1- Th. with marginal carbonized cilia (or marg.rhizines)..**16**

2- Th. with pseudocyphellae on the upper surface and/or on the margins................................**3**(++)

(+)See Hale (32,33). A very useful way to differentiate sterile specimens of Flavoparmelia and Xanthoparmelia would be to look for lichenin in medullary hyphae. The species of the latter have lichenin, those of the former lack it; but the test for lichenin was not yet published.

(++)In several species of Parmelia s.str. (point 6) the pseudocyphellae are actually not open (covered by a polysacharidic roof), but ontogenetically they may open at maturity and expose the medulla).

2- Th. without pseudocyphellae, neither on the upper surface nor on the margins..........................7

3- Medulla only with fatty acids.........................4

3- Medulla with other types of compounds as main characteristic substances; if fatty acids are present, they are accesory..5

4- Caperatic acid as main medullary substance; pycnidia, when present, marginal...................**PLATISMATIA** (four species,4)

4- Medullary fatty acids different from caperatic acid; pycnidia laminal, immersed.................**PUNCTELIA** (42)

5- Characteristic medullary substances: alectoronic, anziaic, α-collatolic, imbricaric, microphyllinic, olivetoric and perlatolic acids; pycnidia, when present, marginal.......................................**CETRELIA** (4)

5- Medullary substances different from the former (in point 5); pycnidia laminal, immersed..................6

6- Medulla with gyrophoric or lecanoric acids as main characteristic substances; pseudocyphellae mainly punctiform (orbicular, oblong or irregularly elongate, branched or not)........................**PUNCTELIA** (42)

6- Medulla mostly with salazinic acid, replaced or accompanied by lobaric, echinocarpic, protocetraric, fumarprotocetraric, and/or fatty acids; pseudocyphellae mostly effigurate(+)...........**PARMELIA s.str.** (34)

7- Anthraquinones and higher aliphatic acids as main medullary substances; pycnidia marginal and laminal; apothecia abundant, at first marginal, finally laminal (Northamerican endemism, one species)...........**ESSLINGERIANA** (46,12,9)

(+) In Parmelia s. str. three types od pseudocyphellae are actually found: in three Asiatic species they are only punctiform, orbicular and very small; in several other species they are only marginal (sometimes forming a continous margin) and in the bulk of species they are laminal, effigurate and marginal (the laminal ones may be mixed with punctiform ones).

7- Caperatic acid as main medullary substance; pycnidia, when present, marginal or submarginal; apothecia mostly laminal, rarely marginal.............**PLATISMATIA** (4)

7- Other substances as main medullary compounds (if caperatic acid is present, then it is accesory; fatty acids of the reddenda group may be found, with Rf between caperatic and protolichesteric acids); apothecia mostly laminal from the begining (in one genus (Parmelaria, point 17) the apothecia may also be submarginal but the pycnidia are marginal..............................8

8- Th. without atranorin in the upper cortex or only traces present......................................9

8- Th. with atranorin in the upper cortex in easily detectable ammounts (very rarely surface K-).......10

9- Th. small (2-5 cm diam.) tightly adnate, with lobes 1 mm broad; simple rhizines on the lower surface, thamnolic acid as the only medullary substance (there is no cortical substance).........................**IMSHAUGIA** (38,49,48)

9- Th. small or large, tightly or loosely adnate, lobes mostly more than 1 mm wide; rhizines mostly dichotomously branched; medullary substances different from thamnolic acid; lichexanthone as cortical substance (upper cortex UV+ orange-yellow with long wave UV).**HYPOTRACHYNA** (21)

10- Th. without rhizines on the lower side; alectoronic acid in the medulla..........................**ASAHINEA** (two species;2)

10- Th. with rhizines on the lower side; different substances in the medulla, including alectoronic acid too...11

11- Lower side with mostly dichotomously branched rhizines. ....**HYPOTRACHYNA** (43,21,18)

11- Lower side with rhizines of different types; if some dichotomously branched, they do not predominate.......12

12- Pycnidia with falcate conidia; spores reniform to allantoid; thallus small (2-5 cm diam.), lobes narrow (1 mm wide), divaricatic acid in the medulla......... ....**PARMELIOPSIS** (P.hyperopta; 38,49 48,26)

12- Conidia of different forms, never falcate ; spores neither reniform nor allantoid; thallus small or large, lobes of different widths (0.5-25 mm); medullary substances of different types, including divaricatic acid.......................................**13**

13- Th. generally loosely appressed and adnate , lobes broad, infrequently of medium width, (3-) 5-15 (-25) mm...**PARMOTREMA** (44,19,15)

13- Th. generally appressed to tightly appressed and adnate (infrequently loosely adnate), lobes narrow or of medium widths, (0.5-) 1-5 (-8) mm..............................**14**

14- Upper cortex and medulla with secalonic acid A (yellow pigment); lobes subirregular, apically rotund, 1-4 mm wide; spores 4-7 X 6-9 (-10) µm; conidia slightly bifusiform or filiform (12-20 µm long)...... ....**PSEUDOPARMELIA s.str.** (33,8,24)

14- Upper cortex and medulla without secalonic acid A. Conidia shorter (with some exceptions,+).........**15**

15- Lobes sublinear to subirregular (0.5-) 1-3 (-4) mm wide Th. saxicolous. Spores 4-6 X 7-10 (-13) µm, conidia bifusiform, 5-7 µm long.....................**PARAPARMELIA** (8,20,24)

15- Lobes subirregular, apically rotund (0.5-) 3-5 (-8) mm wide. Th. corticolous or saxicolous. Spores 6-8 X (7-) 10-14 (-16) µm. Conidia bifusiform to sublageniform (5-) 7-10 um long, infrequently filiform (+) 6-22 µm long (+).........................**CANOPARMELIA** (8,20,24)

16- Margin of the lobes with bulbate cilia; thallus generally small with narrow lobes........**BULBOTHRIX** (25,17)

16- Margin of the lobes with simple, not bulbate cilia or marginal rhizines **17**

17- Th. with marginal verruciform pycnidia; lobes broad, 5-10 (-15) mm; thallus loosely adnate; alectoronic acid in the medulla (two species from the Himalaya).... ....**PARMELARIA** (1)

17- Th. with laminal immersed pycnidia (frequently grouped near submarginal areas). Lobes of different widths and diverse substances in the medulla, including also alectoronic acid....................................**18**

(+) In Canoparmelia texana the conidia are cylindrical (short filiform) 6-8 µm long; in C. crozalsiana, long filiform, 10-22 µm long as in C. carneopruinata, 11-16 µm long.

18- Lecanoric acid in the medulla as the major characteristic substance (except in one species (+))...**19**

18- Other substances (different from lecanoric acid) in the medulla....................................**20**

19- Lobes mostly narrow to medium (infrequently broad), 1-4 (-6) mm. Th. adnate to tightly adnate; spores less than 12 µm long; cilia sparse and short (0.2-1 mm long) in the lobe axils...............**PARMELINA s.str.** (6,26)

19- Lobes broad (8-20 mm), infrequently of medium width; th. generally loosely adnate; spores more than 12 µm long (rarely less than 10 µm long); cilia (0.3-) 1-4 (-5) mm long).............................**PARMOTREMA** (44,19,15)

20- Medulla orange-yellow, sulfur-yellow (at least in part), infrequently white or pale greenish-yellow. Characteristic chemistry: combined presence of the following substances: a) zeorin, b) leucotylin or leucotylic acid, c) secalonic acid A (one or two of these alternatives may be absent(++). Lobes adnate to tightly adnate, apically rotund (0.5-) 1-4 (-6) mm wide; cilia short (less than 0.8 mm long) in the lobe axils(+++)............**MYELOCHROA** (6,26)

20- Medullary chemistry different from point 20 above; if the medulla is yellow, the lobes are more than 5 mm wide. Lobes may be narrow, broad or of medium width, closely or loosely adnate; the cilia (or marginal rhizines) are mostly more than 1 mm long (but shorter ones,0.1-0.8 mm, may be mixed with the longer ones)....................................**21**

21- Lobes linear or sublinear, plane to canaliculate,narrow or of medium width (0.2-) 0.5-4 (-6) mm, dichotomous, subdichotomous or irregularly divided, with truncate or subacute apices..................................**22**

(+) In Parmelina endoleuca (Parmelina s.str.) there are fatty acids in the medulla, instead of lecanoric acid.
(++) In one species (M.immiscens), a),b) and c) are lacking and are replaced by non identified pigments. Secalonic acid A=entothein.
(+++) Sometimes the cilia are so reduced that they may be overlooked.

21- Lobes subirregular or irregular with rotund or subrotund apices (lobes may be laciniate or deeply incised), generally plane,(2-) 4-15 (-25) mm wide (narrow to broad)..**24**

22- Upper surface notoriously maculate-stippled (white, more or less orbicular spots) feature corresponding with an upper cortex (in transverse section) interrupted by intrusion of algal packets (+) (the white spots correspond with the thicker parts of the cortex). Lobes narrow, 1-2 (-4) mm wide, dichotomously or subdichotomously branched; marginal rhizines sparse (two species from SE South America). ....**CONCAMERELLA** (5)

22- Upper surface not maculate or slightly maculate; upper cortex not deeply interrupted by intrusion of algal packets. Lobes narrow, less frequently of medium size, the apices truncate or subacute; cilia or marginal rhizines very sparse to dense..**23**

23- Lobes sublinear, dichotomous or irregularly branched, narrow, 0.5-1.5 (-3) mm wide. Medulla rarely with salazinic acid (++) as characteristic substance. Most frequent medullary chemistry: fatty acids or gyrophoric acid (frequently accompanied by related substances,e.g. 3-methoxy-2,4-di-O-methyl-gyrophoric acid ("horrescens unknown"), 5-O-methyl-hiascic acid, 2,4,5-tri-methyl-hiascic acid). Apothecia adnate with ellipsoid spores (5-) 8-12 X (10-) 12-18 µm...............**PARMELINOPSIS** (6,26)

23- Lobes sublinear (0.2-) 0.5-4 (-6) mm broad, subdichotomously branched. Medulla only with fatty acids related to protolichesteric acid. Apothecia with a solid stalk (the lower cortex not forming a sinus below the apothecium). Asci 11-14 X 25-36 µm; spores spherical to subglobose, 5-6 X 9-12 (-13) µm in two of the three species, (4-) 5 X 5-8 µm in the third species...**CETRARIASTRUM** (51,50,5)

(+) Vaulted cortex (5).

(++) Two species of Parmelinopsis contain salazinic acid: P. swinscowii and P. radiculata.

23- Lobes linear, freq. canaliculate and with long internodes, dichot. branched; medulla freq. with fatty acids which may be accompanied by salazinic or protocetraric acids, infrequently by gyrophoric acid. Apothecia stipitate with a hollow stalk. Asci (15-) 20-25 (-35) X (30-) 40-60 (-75) µm; spores (4-) 6-7 (-11) X (7-) 10-16 (-28) µm, the larger ones, reniform..**EVERNIASTRUM** (55,50,23)

24- Upper surface conspicuously effigurate or stippled-maculate. Upper cortex thick, deeply interrupted with algal packets (similar to a vaulted cortex). Lobes subirregular, apically rotund or subrotund, appressed and adnate, 2-6 mm wide, sometimes laciniate. Marginal cilia coarse, tapered, up to 1.5 mm long; conidia cylindrical to filiform..**CANOMACULINA** (6,26)

24- Upper surface emaculate. Upper cortex thick, coriaceous, but continuous (not vaulted). Lobes of medium width or broad, (3-) 4-10 mm, appressed and adnate, irregular, with rotund apices; cilia sparse, slender, more or less restricted to the lobe axils; medulla with salazinic acid; conidia cylindrical, 5-9 µm long..............**PARMELINELLA** (6,26)

24- Upper surface emaculate. Upper cortex thin, continuous, more or less flaking. Lobes irregular or subirregular, adnate, apically rotund, (3-) 4-10 mm wide; cilia sparse, less than 0.5 mm long, more or less restricted to the lobe axils; medulla with norstictic and connorstictic acids; conidia cylindrical, 3-5 µm long............**PARMOTREMOPSIS** (6,26)

24- Upper surface emaculate, or maculate with reticulate or effigurate macules or with green stippling; lobes generally broad (3-) 5-15 (-25) mm, cilia slender, short or long (freq. more than 0.8 mm). Medullary chemistry diverse (salazinic or norstictic acids may be present). Conidia cylindrical, filiform or sublageniform...............**PARMOTREMA** (44,15)

KEY C

Thallus pale to dark straw, reddish, greenish or blackish brown (brown or dark green pigments in the K- upper cortex); absence of either atranorin or usnic acids.

1- Th. fruticose, formed by erect, plane to canaliculate or subtubular lobes; upper or lower cortex brown, variable, to greyish or almost white. Pseudocyphellae often present, especially on the lower cortex. Marginal projections often present and bearing the pycnidia...**CETRARIA** (the brown fruticose Cetrariae,40)

1- Th. foliose appressed.....................................2

2- Th. cartilaginous, lying free on soil; lower side partly ecorticate (one genus of the tundra)**MASONHALEA** (39)

2- Th. not cartilaginous, constituted by lobes appressed against the substrate and adnate to it; lower side wholly corticate, bearing true rhizines (rarely reduced in a few, almost subcrustose species; only in four species the foliose thallus tends to a subfruticose habit)....................................3

3- Upper cortex (the surface studied with SEM) with a pored epicortex; pseudocyphellae absent................4

3- Upper cortex (studied with SEM) with a non pored epicortex; some species with pseudocyphellae (frequently restricted to laminal warts or to the lobe apices; all species have an upper cortex reacting HNO$_3$ -)..**MELANELIA** (47,41,11,10)

4- Upper cortex HNO$_3$ + blue-green (rarely HNO$_3$ + violet, in two species). Conidia bifusiform.......**NEOFUSCELIA** (47,11,10)

4- Upper cortex HNO$_3$ - (or HNO$_3$ + pale violet in some parts of the thallus). Conidia cylindrical or sublageniform................................**PLEUROSTICTA** (47,41,11,10)

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NEW RECORDS OF *LACTARIUS* FROM MEXICO AND DISCUSSION OF THE KNOWN SPECIES

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ABSTRACT

Nine previously unreported species and varieties of *Lactarius* from Mexico are presented: *L. eburneus* var. *ervinii* Hesler & A. H. Sm., *L. fragilis* (Burl.) Hesler & A. H. Sm., *L. gerardii* var. *fagicola* (A. H. Sm. & Hesler) Hesler & A. H. Sm., *L. gerardii* var. *subrubescens* (A. H. Sm. & Hesler) Hesler & A. H. Sm., *L. lacunarum* (Romag.) Hora, *L. lignyotellus* A. H. Sm. & Hesler, *L. sublacustris* Hesler & A. H. Sm., *L. subplinthogalus* Coker and *L. subvellereus* var. *subdistans* Hesler & A.H. Sm. In addition, five species previously known from Mexico are reported from new localities: *L. deceptivus* Peck var. *deceptivus* from the States of Puebla and Veracruz, *L. fuliginellus* A. H. Sm. & Hesler and *L. gerardii* Peck var. *gerardii* from Veracruz, *L. hygrophoroides* Berk. & Curtis var. *hygrophoroides* from Baja California Sur and Veracruz, and *L. uvidus* (Fr. : Fr.) Fr. var. *uvidus* from Guerrero, Hidalgo and Veracruz. A check list of the 36 species and varieties previously known from Mexico is also discussed.

INTRODUCTION

The genus *Lactarius* is well represented in the *Quercus* and coniferous forests of Mexico. Of the 36 known species, only 2 are from tropical forests (*L. veraecrucis* Sing. and *L. neotropicus* Sing.). To date, however, there are few studies devoted to these fungi in Mexico. The only work dealing exclusively with the genus *Lactarius*, as it occurs in Mexico is that of Guevara et al. (1987), where 10 species were described. Also, Guzmán (1977) considered 17 species.

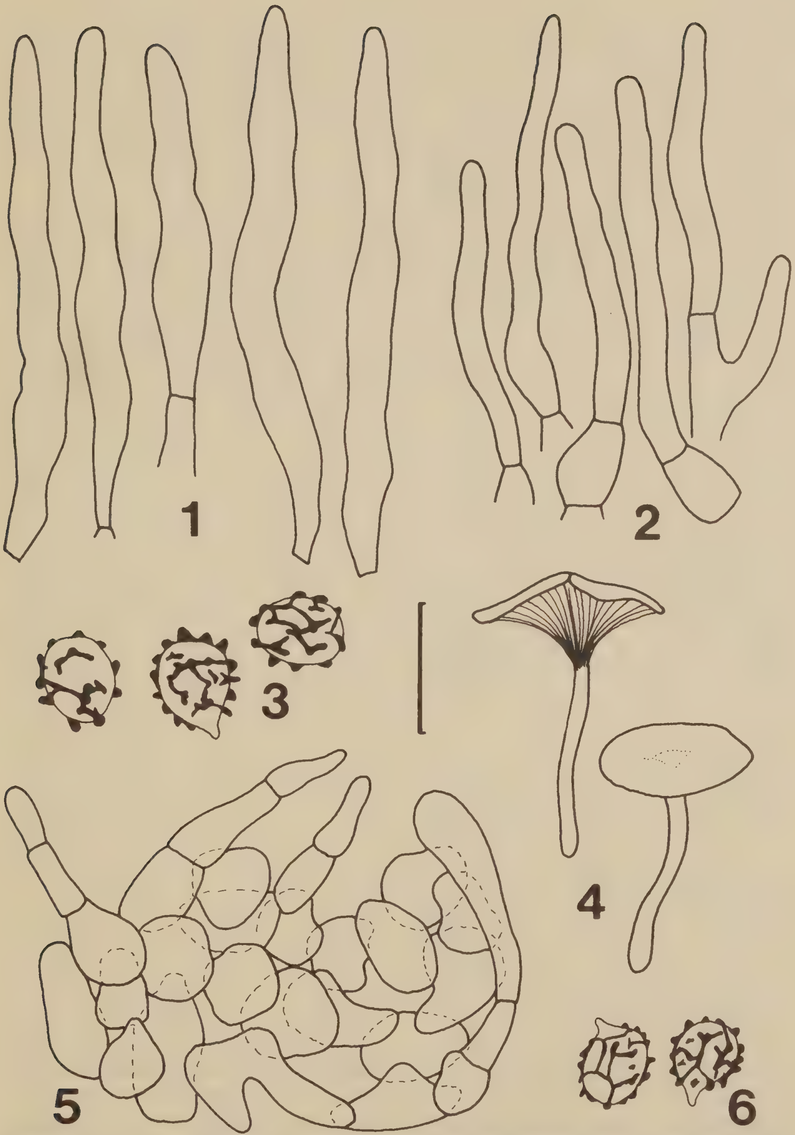
The present paper provides descriptions of 9 new records of *Lactarius* from Mexico, and 5 previously known species are reported from new localities, based on a study of more than 40 herbarium specimens collected in coniferous, *Quercus* and subtropical (mesophytic) forests in the States of Baja California Sur, Chiapas, Guerrero, Hidalgo, Puebla, and Veracruz. Microscopic study was made on dried materials, using Largent et al. (1977) techniques. Slides were mounted in 5 % KOH and in reagent of Melzer. Spores size and ornamentation high are considered separatedly. Colors in the descriptions are based on Rayner (1970). The specimens examined are deposited in ENCB, FCME and XAL Herbaria.

DESCRIPTIONS OF THE NEW RECORDS

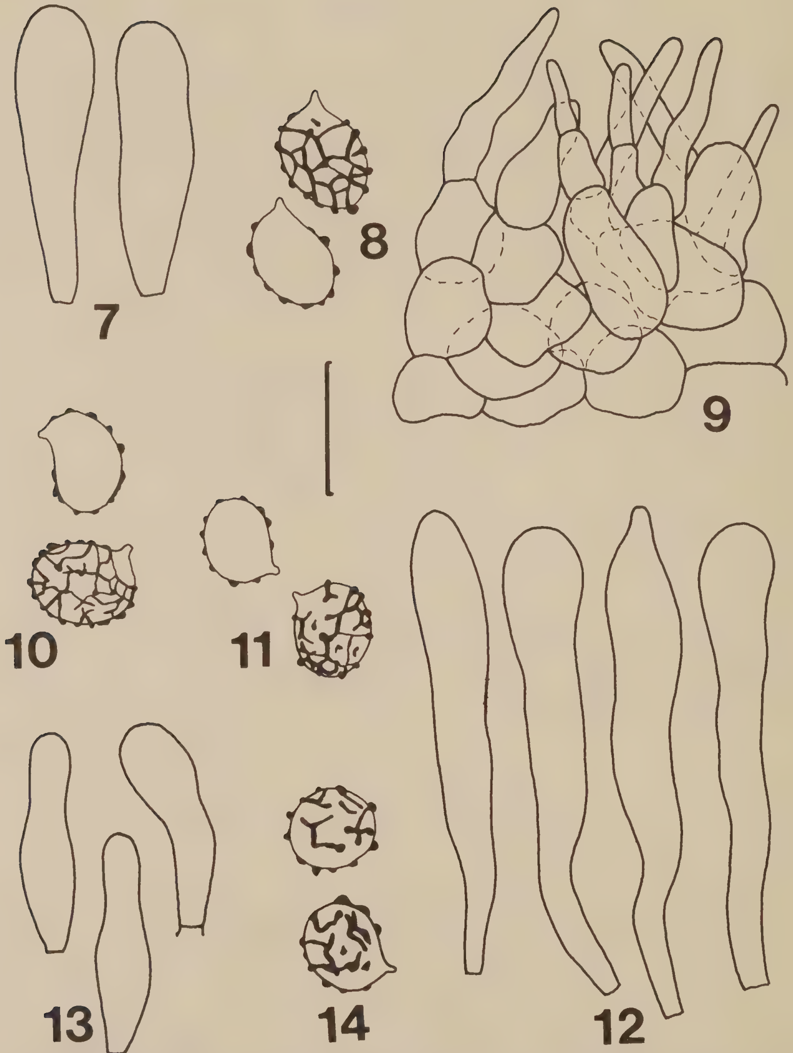
1. *Lactarius eburneus* var. *ervinii* Hesler & A. H. Sm., North American Species of *Lactarius*, p. 156, 1979.

Figs. 1-3 and 50

Pileus approximately 10-40 mm in diam., plano-convex, depressed in the center; margin incurved; surface smooth, glabrous to slightly velvety, pale brown to greyish brown (hazel to greyish sepia 17'''/17''''). Lamellae adnexed, close, whitish to very pale yellowish brown (buff 19''f) with pinkish tinges, slowly staining salmon pink when cut. Stipe



Figs. 1-6.- 1-3: *Lactarius eburneus* var. *ervinii*, 1: cheilocystidia, 2 caulocystidia, 3: spores. 4-6: *L. fragilis*, 4: basidiocarps, 5: pileus cuticle, 6: spores (1-3: Montoya 735; 4-6: Sampieri 991) (1: bar=13 µm; 2: bar= 16 µm; 3, 6: bar= 10 µm; 4: bar= 20 mm; 5: bar= 17 µm).



Figs. 7-14.- 7: *Lactarius fragilis*, cheilocystidia. 8: *L. gerardii* var. *fagicola*, spores. 9-12: *L. gerardii* var. *subrubescens*, 9: pileus cuticle, 10-11: spores, 12: pleurocystidia. 13-14: *L. lacunarum*, 13: cheilocystidia, 14: spores (7: Sampieri 991; 8: Medel 39; 9-10, 12: Montoya 894; 11: Bandala 1152, 13-14: Sampieri 952) (7, 13: bar= 17 µm; 8, 10, 11, 14: bar= 10 µm; 9, 12: bar= 20 µm).

approximately 15-25 x 5-7 mm, cylindric; surface smooth, pale greyish brown (pale greyish sepia 17''''). Context whitish, changing to salmon; taste not distinctive; slight odor of chlorine. Latex white, staining the cut surfaces pinkish salmon (rosy buff 15''f).

Spores (7-) 8-9 x (6-) 7-8 µm, subglobose, hyaline, ornamentation a broken reticulum 1-1.5 µm high, amyloid. Basidia 46-50 x 9-12 µm, clavate, hyaline, tetrasporic. Pleurocystidia absent. Cheilocystidia (24-) 43-75 x 5-7 µm, numerous, cylindric-subfusiform with acute apex, flexuous, hyaline. Pileus cuticle consisting of 2-3 basal layers of globose cells 10-25 µm in diam., pale yellowish brown to hyaline; surface with cystidioid cells of 35-40 x 3-5 µm, cylindric or subclavate, pale yellowish brown. Stipe cuticle of parallel or interwoven hyphae 4-6 µm in diam., hyaline to yellowish; caulocystidia 25-55 x 4-5 µm, cylindric and flexuous, more or less erect or interwoven, pale yellowish brown, sometimes with subglobose or subventricose basal cells 7-9 µm in diam. Context hyphae 4-10 µm in diam., yellowish; sphaerocysts 10-25 (-35) µm in diam. Hymenophoral trama hyphae 3-5 µm diam., yellowish; laticifers 5-24 µm in diam.

HABITAT. In soil, gregarious to cespitose in mesophytic forest; at 1300 m alt., fruiting in August.

SPECIMEN EXAMINED: VERACRUZ, km 2.5 old road from Xalapa to Coatepec, Parque Ecológico Francisco J. Clavijero, Montoya 735 (XAL).

DISCUSSION. This variety can be distinguished of the typical variety which presents shorter cheilocystidia (28-45 x 3-7 µm), stronger ornamentation of the spores (0.8-2.3 µm or 1-3 µm) and unchanging context (Hesler & Smith, 1979). *L. eburneus* var. *ervinii* is reported here for first time from Mexico.

2. *Lactarius fragilis* (Burl.) Hesler & A. H. Sm., North American Species of *Lactarius*, p. 503, 1979 var. *fragilis*

Figs. 4-7

Pileus 15-45 mm in diam., plano-convex, with a slight central depression; surface velvety, hygrophanous, brownish orange, cinnamon brown to pale salmon brown (fulvous 11'i or dark cinnamon to umber 15''/15'i). Lamellae decurrent, subclose, pale orange brown (pale fulvous 11'i). Stipe 23-30 x 2-5 mm, cylindric, sometimes flattened; surface glabrous to slightly velvety, concolorous with the pileus. Context whitish to pale orange brown (pale fulvous 11'i); odor strongly of camphor or of nuts, persisting in dried condition; taste pleasant. Latex watery, copious.

Spores 6.5-7.5 x 6.5-7 µm, globose to subglobose, ornamentations amyloid forming a reticulum 0.5-1 µm high. Basidia 40-45 (-62) x 9-11 (-12) µm, clavate, 1- to 4-spored, hyaline. Pleurocystidia absent. Cheilocystidia 25-40 x 9-12 µm, numerous, clavate, hyaline. Pileus cuticle of globose or irregularly globose cells, (5-) 9-15 µm diam., thin-walled, hyaline; pileocystidia 19-23 (-45) x 7-12 µm, numerous, clavate, cylindric to pyriform, hyaline. Context hyphae 5-22 (-33) µm diam., cylindric, branched, septate; laticifers more or less numerous 2.4-4 (-5) µm diam. Hymenophoral trama irregular, consisting of hyphae 3-6 (-12) µm diam., branched, hyaline; laticifers (1.6-) 2.4-3.2 (-4) µm diam.

HABITAT. In soil, gregarious in *Quercus* and mesophytic forests; at 1400 m alt., collected during June-August.

SPECIMENS EXAMINED: VERACRUZ, Municipio Huatusco, road from Huatusco to Elotepec, Rancho San Rafael, Sampieri 991. Municipio Chiconquiaco, road from Naolinco to Misantla, 1 km before Chiconquiaco, Bandala 872; Montoya 640 (all in XAL).

DISCUSSION. *L. fragilis* is distinguished by the size and shape of the spores, structure of the pileus cuticle and strong odor which persists even in dired basidiocarps. Hesler and Smith (1979) pointed out that this odor persists in herbarium specimens preserved for more than sixty years. This odor is similar to that of *L. camphoratus* (Bull. : Fr.) Fr. which is widely distributed in Mexico (Guzmán, 1977; Ayala and Guzmán, 1984; López et al., 1985; Frutis-Molina et al., 1985). The later species differs from *L. fragilis* var. *fragilis* by its elliptical spores 7-8.5 x 6-7.5 µm and milky latex (Hesler and Smith, 1979). Probably several Mexican specimens reported as *L. camphoratus* correspond to *L. fragilis*. Another similar species is *L. lacunarum* (Romagn.) Hora, but in this species the latex changes to yellow and the pileus cuticle is gelatinized (see below). This is the first record of *L. fragilis* var. *fragilis* from Mexico.

3. *Lactarius gerardii* var. *fagicola* (A. H. Sm. & Hesler) Hesler & A. H. Sm., North American Species of *Lactarius*, p. 112, 1979.

Fig. 8

Pileus 10-65 mm in diam., convex, slightly depressed centrally; surface rugose, faintly velvety, dark brown to blackish brown (dark umber to sepia 15m/15''k or pale fuscous black 7''''k). Lamellae adnexed to slightly decurrent, distant, white to yellowish, staining brown or violaceous brown when bruised, broad; margin entire. Stipe 37-60 x 5-12 mm, cylindric; surface subvelvety, whitish at lamellar attachment and at base, otherwise concolorous with the pileus surface. Context whitish, staining brown when exposed; odor pleasant; taste mild. Latex white, staining the surfaces brown when exposed.

Spores 7-10 x 7-8 µm, subglobose to subelliptic, hilar appendage 1-2 µm long, hyaline, with an amyloid reticulum 0.5 (-1) µm high. Basidia 36-68 x 12-15 µm, 1- or 4-spored, clavate, hyaline. Pleurocystidia and cheilocystidia absent, only hyaline, thin-walled clavate cells, similar to basidioles present. Pileus cuticle consisting of 2-5 layers of globose cells 8-23 µm in diam.; pileocystidia 19-25 x 4-10 µm, cylindric or clavate, brown to yellowish brown. Context hyphae 4-6 µm in diameter, hyaline; laticifers 3-8 (-14) µm diam.; sphaerocysts 20-30 (-40) µm diam., hyaline. Hymenophoral trama of irregular, cylindric hyphae 4-6 µm diam.; laticifers (5-) 7-12 µm in diam. Stipe cuticle of 2-3 layers of yellowish to brown globose cells 7-13 µm in diam.; caulocystidia 18-42 x 5-7 µm, clavate to subcylindric, yellowish brown.

HABITAT. In soil, solitary in mesophytic forests; at 1300-1650 m alt., collected during May and September.

SPECIMENS EXAMINED: VERACRUZ, km 2.5 old road from Xalapa to Coatepec, Parque Ecológico Francisco J. Clavijero, Brown 449. Municipio Rafael Lucio, km 10 road Xalapa to La Joya, Granja Santa Barbara, Medel 39 (both in XAL).

DISCUSSION. The studied specimens agree with Hesler and Smith (1979) in terms of the staining of the context and lamellae. However, they reported slightly larger spores (8-11 x 7-10 µm) and some 6-8 µm wide. They also observed rare pleurocystidia, pointing out that these structures could be monosporic basidia and therefore without taxonomic importance. This variety is the first record from Mexico.

4. *Lactarius gerardii* var. *subrubescens* (A. H. Sm. & Hesler) Hesler & A. H. Sm., North American Species of *Lactarius*, p. 114, 1979.

Figs. 9-12

Pileus 13-120 mm in diam., plane, with a slight central depression, sometimes with a small, acute papilla; surface rugose, velvety, dark brown to yellowish brown (dark umber or sepia 15m/15''k or isabelline honey 19''i to 21''b); margin faintly striate. Lamellae subdecurrent to decurrent, broad, distant, with some small transverse veins, cream yellow (near pale luteous 9f), instantaneously or slowly staining reddish when bruised. Stipe 10-70 x 3-12 mm, cylindric to somewhat attenuated at the apex, sometimes faintly striate at the apex, concolorous with pileus surface, sometimes with whitish spots. Context whitish, staining reddish when cut after some minutes; odor fungoid; taste faintly acrid. Latex milky, slowly staining the cut surfaces reddish, sometimes reddish tinges remain apparent in dried basidiocarps. Spore print white. 5 % KOH staining latex, lamellae and context yellowish, negative on pileus surface.

Spores 7-10 (-11) x 7-9 µm, subelliptic to subglobose, hyaline, with a reticulum 0.2-0.5 µm high, amyloid. Basidia 48-65 x 8-10 µm, 2- or 4-spored, clavate. Pleurocystidia 67-82 x 8-12 µm, clavate to subfusoid, capitate or mucronate, rare. Pseudocystidia 2-6 µm wide, subcylindric, hyaline. Cheilocystidia basidiole-like, 20-40 (-43) x 5-9 µm, clavate, hyaline, thin-walled. Pileus cuticle of 3-4 layers of subglobose cells, 8-32 µm in diam., yellowish brown; pileocystidia 11-42 x 4-9 µm, pyriform, lageniform or subcylindric, hyaline to pale brown. Context hyphae 2-8 µm in diam., cylindric, hyaline to yellowish; sphaerocysts (16-) 19-35 (-45) µm in diam., hyaline; laticifers 4-10 µm diam. Hymenophoral trama irregular, hyphae 4-8 µm diam., hyaline; laticifers 4-8 (-12) µm diam. Stipe cuticle consisting of 2-3 (-4) layers of globose cells, 6-14 (-17) µm diam.; caulocystidia 18-35 (-40) x 4-7 µm, cylindric to subclavate, hyaline to pale brown.

HABITAT. In soil, solitary or gregarious, sometimes cespitose in mesophytic forest; at 1300-1550 m alt., collected during July-October.

SPECIMENS EXAMINED: VERACRUZ, km 2.5 old road from Xalapa to Coatepec, Parque Ecológico Francisco J. Clavijero, Bandala 1152; Montoya 894, 1312. Municipio Banderilla, Cerro La Martinica, Montoya 1376. 2 km SW of Xalapa near the Coapexpan river, Montoya 1407 (all in XAL).

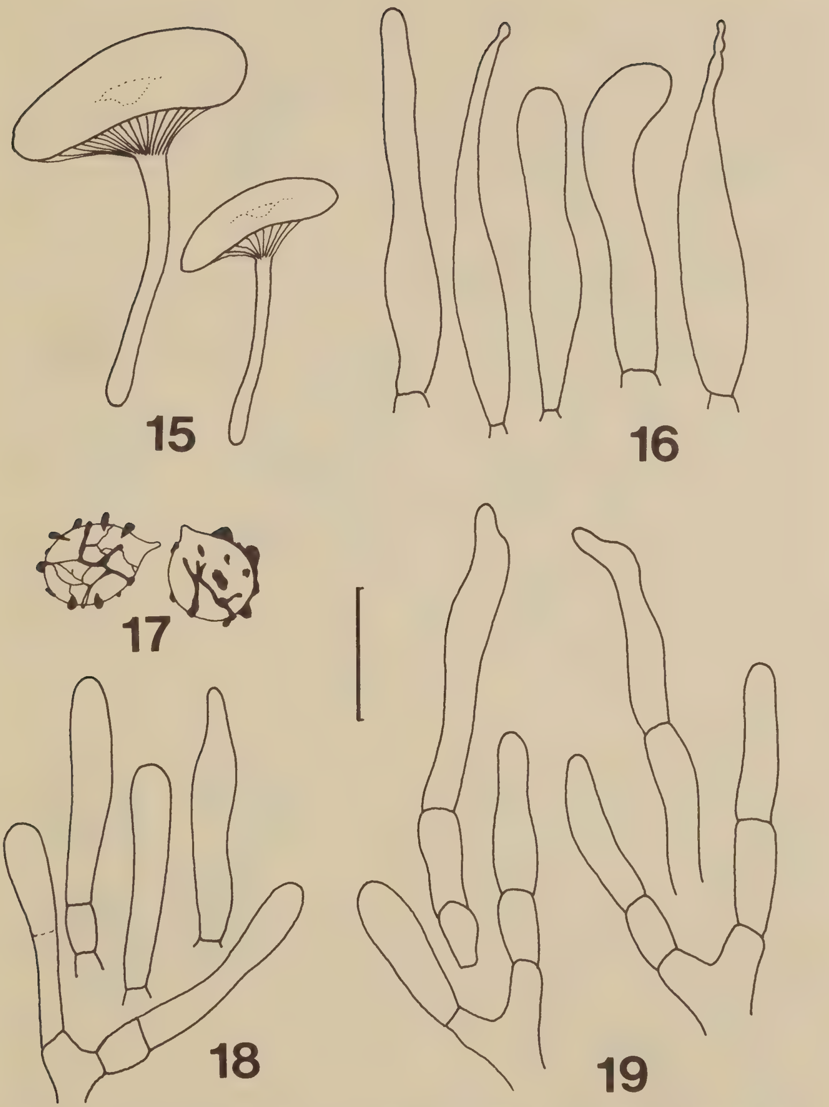
DISCUSSION. The reddish staining context and lamellae distinguish this variety from var. *gerardii* and var. *fagicola*, the context of the former does not stain, while that of the latter stains brown or violet-brown. The specimen Montoya 1312 differs in that the context stains very faint brown in the stipe, and reddish in the pileus. This is the first record of var. *subrubescens* from Mexico, which proof a wider distribution of this variety, from U.S.A. through Mexico.

5. *Lactarius lacunarum* (Romg.) Hora, Trans. Brit. Myc. Soc. 43: 444, 1960.

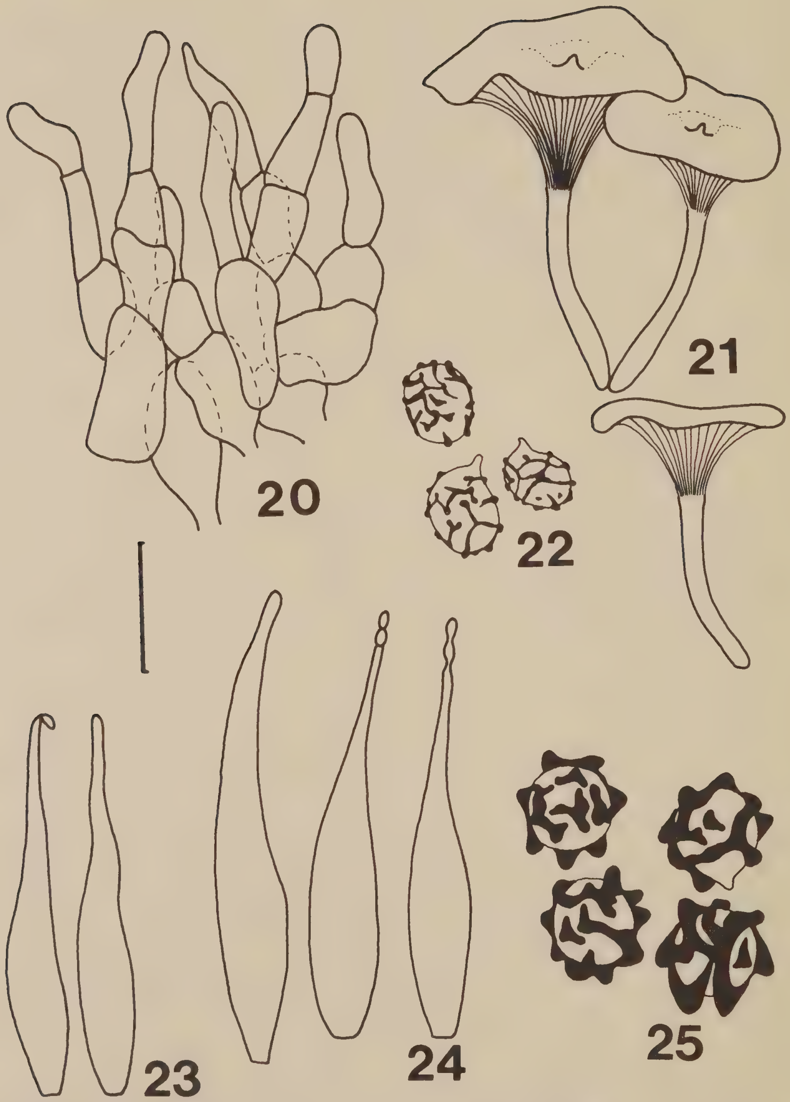
Figs. 13-16 and 49

Pileus 15-45 mm in diam., plano-convex to slightly depressed centrally; surface glabrous, lubricous to dry, reddish brown to orange brown (fulvous 11'i to rust fulvous 9'i). Lamellae subdecurrent, close, narrow, pale orange brown to ferruginous color (pale fulvous 11'i to pale rust 7'i). Stipe 22-45 x 2-5 mm, uniform; surface smooth, glabrous, concolorous with the pileus surface. Context yellowish; odor strongly of nuts even in dried specimens. Latex copious, white, changing to yellow after some minutes when observed on white paper (not conspicuous on the context).

Spores 7-9 x 6-7.5 (-8) µm, subelliptic or globose, hyaline, reticulum incomplete, 0.5-1 µm high, amyloid. Basidia (37-) 42-46 x 8-12 µm, clavate, 4-spored, hyaline. Pleurocystidia 45-62 (-67) x (5-) 7-10 µm, numerous, subcylindric, ventricose, subfusiform or sublageniform, sometimes with constrictions at the apex (moniliform), hyaline. Cheilocystidia 28-30 x 6-9 µm, ventricose to subclavate, hyaline. Pileus cuticle an ixocutis with some erect elements, hyphae 2.4-4.8 (-6.4) µm in diam. Context hyphae 3-7 µm diam., cylindric; sphaerocysts 25-35 (-47) µm in diam.; laticifers 2-6 µm diam. Hymenophoral trama irregular, hyphae 3-6 (-12) µm diam., cylindric, hyaline, thin-walled; laticifers 3-6 µm diam.



Figs. 15-19. 15-16: *L. lacunarum*, 15: basidiocarps, 16: pleurocystidia. 17-19: *L. lignyotellus*, 17: spores, 18: cheilocystidia, 19: caulocystidia (15-16: Sampieri 952, 17-19: Bandala 304) (15: bar= 20 mm; 16, 18: bar= 20 µm; 17: bar= 10 µm; 19: bar= 16 µm).



Figs. 20-25.- 20: *Lactarius lignyotellus*, pileus cuticle. 21-24: *L. sublacustris*, 21: basidiocarps, 22: spores, 23: cheilocystidia, 24: pleurocystidia. 25: *L. subplinthogalus*, spores (20: Bandala 304, 21-24: Montoya 563, 25: Montoya 535) (20: bar= 24 µm; 21: bar= 20 mm; 22, 25: bar= 10 µm; 23, 24: bar= 20 µm).

HABITAT. In soil, gregarious, in *Quercus* and mesophytic forests; at 1600-1700 m alt., collected during August and October.

SPECIMENS EXAMINED: VERACRUZ, km 16 road from Naolinco to Misantla, near Chiconquiaco, Sampieri 952. Municipio Acatlán road Naolinco to Misantla, 3 km from Acatlán, Bandala 632-A (both in XAL).

DISCUSSION. The materials studied agree with the descriptions of Neuhoff (1956), Hesler and Smith (1979), Bon (1979) and Moser (1983). However, Bon not considered a gelatinized pileus cuticle. It is distinguished by its milky latex which changes to yellow, for its pleasant odor (persisting in dried basidiocarps) which is similar to that of *L. fragilis* (Burl.) Hesl. & A. H. Sm., but *L. fragilis* is distinguished by its unchanging latex and non-gelatinized pileus cuticle. *L. lacunarum* was previously known only from deciduos woods in Europe (Hesler and Smith, 1979). Therefore this is a new report for North America. The habitat of Mexican materials agree with that of European specimens.

6. *Lactarius lignyotellus* A. H. Sm. & Hesler, Brittonia 14: 410, 1962

Figs. 17-20

Pileus approximately 12-30 mm in diam., plane to plano-convex, umbilicate; margin irregular; surface subvelvety, dark avellaneous, brownish to dark brown (dark hazel 17''' or dark umber to sepia 15 m/15''k). Lamellae subdecurrent, distant, broad, white with grey brown (greyish umber 15'm) edges. Stipe 25-35 x 5-8 mm, cylindric; surface velvety, concolorous with pileus surface but with white mycelium at the base. Context white, unchanging; odor pleasant; taste not distinctive. Latex white, unchanging.

Spores 8-9 x 7-9 µm, subglobose, hyaline; ornamentation 1-1.3 (-2) µm high, amyloid, forming a nearly complete reticulum or sometimes with isolated warts. Basidia 70-92 x 9-12 µm, subcylindric to subfusiform. Pleurocystidia absent.

Cheilocystidia 24-45 x 6-7 µm, subcylindric, subfusiform or ventricose, flexuous, sometimes with a basal cell or secondarily septate, pale brown. Pileus cuticle of pileocystida 18-40 x 4-7 µm, ventricose to subcylindric, some mucronate, pale brown, occurring as terminal elements of cells arranged in loose or sometimes enlarged rows (but not forming a cellular layer), the cells of 10-23 x 7-14 µm in diam., pale brown. Stipe cuticle of caulocystidia 20-40 x 4-6 µm, ventricose, subclavate, sublageniform, pale brown, in chains arising from parallel hyphae.

HABITAT. Gregarious, in soil in disturbed *Quercus* with *Acacia* forest; at 900-1000 m alt., collected in July.

SPECIMEN EXAMINED: VERACRUZ, 5 km NE of El Lencero, road from Xalapa to Veracruz, Bandala 304 (XAL).

DISCUSSION. The Mexican specimen agrees with the descriptions of Hesler and Smith (1979) and Smith and Hesler (1962), except in the reported pleurocystidia (42-75 x 9-12 µm), however, they pointed out that these structures were very rare in their specimens. This species is distinguished by the colored lamellae edges with pale brown cheilocystidia and the unchanging latex. Guevara et al. (1987) recorded *L. lignyotellus* cf. *texensis* A. H. Sm. & Hesler from the State of Durango, which differs by the reddish staining context, larger spores and narrower caulocystidia. This is the first report of the species from Mexico.

7. *Lactarius sublacustris* Hesler & A. H. Sm., North American Species of *Lactarius*, p. 489, 1979

Figs. 21-24

Pileus 12-40 mm in diam., plano-convex, with a slight central depression to subinfundibuliform, frequently with a central papilla; margin faintly striate; surface viscid, glabrous, orange-brown, cinnamon brown, salmon brown or pinkish cinnamon brown (fulvous 11'i, dark cinnamon to umber

15''/15'i). Lamellae subdecurrent, concolorous with the pileus surface or somewhat paler, irregularly stained with vinaceous pink. Stipe 12-60 x 3-5 mm, concolorous with the pileus surface or paler, smooth. Context pale reddish brown (pale rust fulvous 9'i); odor pleasant, taste mild. Latex white, changing to light yellow after some minutes on white paper (change inconspicuous on the context).

Spores 7-8 x 6-7 µm, subelliptic; hilar appendage 2-3 µm long, hyaline; ornamentation forming a nearly complete reticulum 0.5 (-1) µm high, amyloid. Basidia (33-) 35-52 x 10-12 µm, 4-spored sometimes 1-spored, clavate, hyaline or with granular contents in 1-spored basidia. Pleurocystidia (62-) 69-78 x 10-12 µm, subfusoid to fusoid-ventricose, hyaline but with granular content, thin-walled, smooth; apex subacute or with 1-3 constrictions. Cheilocystidia 58-60 x 8-9 µm, similar to pleurocystidia but the apex less constricted. Pileus cuticle hyphae 2-3 (-4) µm in diam., branched, gelatinized, interwoven. Context hyphae 4-7 µm diam., cylindric, hyaline; laticifers (2-) 4-5 (-7) µm diam., numerous; sphaerocysts 15-20 µm in diam., rare. Hymenophoral trama irregular, hyphae 2-4 (-7) µm in diam., cylindric, hyaline; laticifers (2-) 4-6 µm in diam.

HABITAT. In soil, gregarious in mesophytic forest; at 1340 m alt., collected during June and September.

SPECIMEN EXAMINED: VERACRUZ, 2 km SW of Xalapa, near the Coapexpan river, Montoya 563; Bandala 1025 (both in XAL).

DISCUSSION. This species is distinguished by the pileus color, lamellae which stain vinaceous pink, change in color of the latex, from white to yellow on white paper, and mild taste. Hesler & Smith (1979) considered of importance also, the small spores (7-8 x 5-6 µm) and the white spore deposit, this last feature was not checked in the Mexican materials. This is the first record of *L. sublacustris* from Mexico.

8. *Lactarius subplinthogalus* Coker, J. Elisha Mitchell Sci. Soc. 34: 50, 1918.

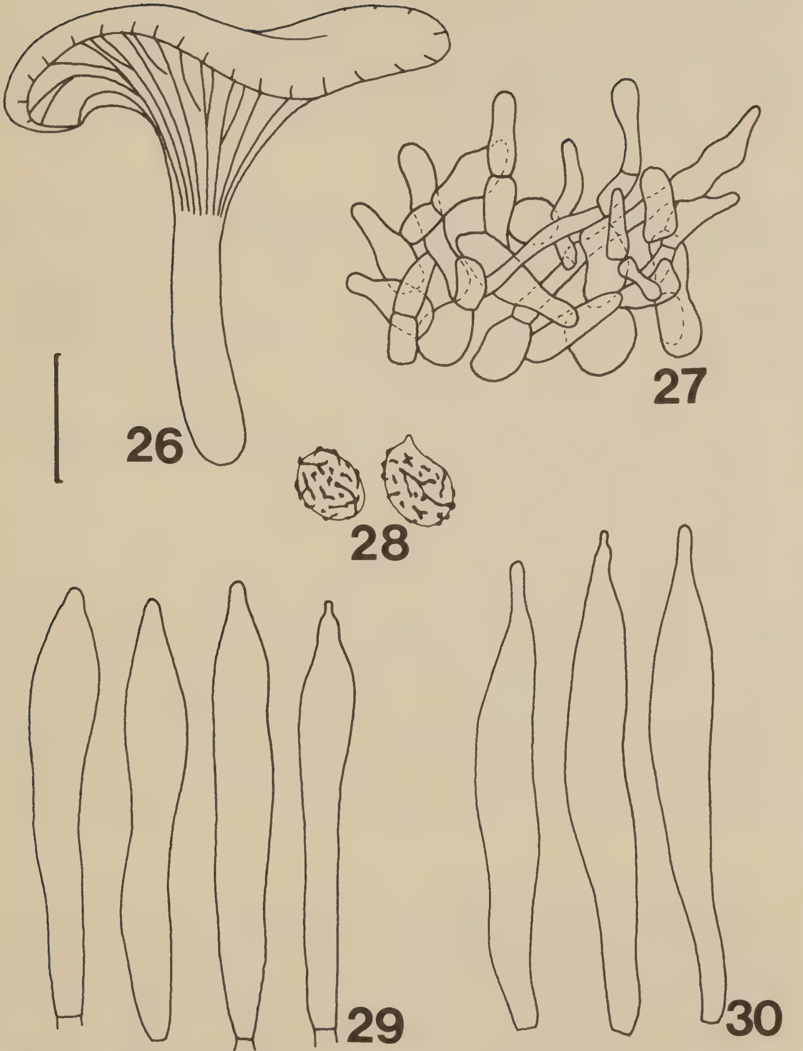
Figs. 25-27 and 51

Pileus 75-120 mm in diam., plane or plano-convex, some centrally depressed; margin undulated, striated, occasionally incurved; surface smooth to centrally rugose, glabrous to faintly velvety, yellowish brown, pale yellowish brown or some greyish brown (pale hazel 17''' to isabelline 19''i). Lamellae adnexed to shortly subdecurrent, thick and broad, distant, straw color to pale yellowish brown or brownish orange to ochraceous (pale honey to pale ochraceous 21''b to 17'b). Stipe 50-70 x 10-12 mm, cylindric, attenuated at the base; surface smooth to velvety, concolorous with the pileus surface or paler. Context whitish to concolorous with lamellae; taste acrid; odor faintly of chlorine. Latex milky, staining cut surfaces red to salmon pink, taste acrid.

Spores 7-9 (-10) x 7-8 (-10) µm, subglobose to elliptic, hyaline; ornamentation of heavy ridges and warts, forming an incomplete reticulation, 2-3 µm high. Basidia 55-67 (-70) x 10-14 µm, 2- or 4-spored, clavate, hyaline, smooth. Pleurocystidia absent. Cheilocystidia 21-27 x 6-7 µm, subcylindric to subclavate, slightly flexuous, hyaline, rare. Pileus cuticle consisting of globose cells 7-12 µm diam. and subcylindric, clavate or ventricose elements (15-) 17-35 x 6-12 µm, pale yellowish brown. Context hyphae 3-7 µm diam.; sphaerocysts 20-40 (-45) µm in diam., more or less numerous, hyaline; laticifers (3-) 5-11 µm diam. Hymenophoral trama irregular, hyphae (2-) 3-5 (-7) µm diam., cylindric, hyaline, smooth, thin walled; laticifers (3-) 5-10 µm diam., numerous; sphaerocysts 15-25 (-30) µm in diam., rare.

HABITAT. In soil, solitary or gregarious in mesophytic forest; at 1300-1700 m alt., collected during May to September.

SPECIMENS EXAMINED: VERACRUZ, Municipio Banderilla, Cerro La Martinica, Montoya 1379, 1546.



Figs. 26-30.- 26-27: *Lactarius suplinthogalus*, 26: basidiocarp, 27: pileus cuticle. 28-30: *L. subvellereus* var. *subdistans*, 28: spores, 29: pleurocystidia, 30: cheilocystidia (26-27; Montoya 535, 28-30: Sampieri 851) (26: bar= 20 mm; 27: bar= 22 µm; 28: bar= 10 µm; 29: bar= 15 µm; 30: bar= 14 µm).

Municipio Ixhuacan de Los Reyes, road from Teocelo to Cosautlán, Amatla, Montoya 535. Municipio San Andrés Tlalnehuayocan, 10.7 km by the road from San Andrés Tlalnehuayocan to Plan de Sedeño, Montoya 670. 2.5 km old road from Xalapa to Coatepec, Parque Ecológico Francisco J. Clavijero, Anell 483 (all in XAL).

DISCUSSION. The specimens studied agree with the description in Hesler and Smith (1979). This species is distinguished by the acrid taste, the staining of the surface by the latex, the structure of pileus cuticle, and the heavy spore ornamentation. This is a very common fungus, which was not reported from Mexico.

9. *Lactarius subvellereus* Peck. var. *subdistans* Hesler & A. H. Sm., North American Species of *Lactarius*, p. 203, 1979

Figs. 28-31 and 52

Pileus approximately 55-105 mm in diam., subinfundi- buliform; margin inrolled; surface tomentose, white to yellowish white or yellowish in dried condition. Lamellae adnexed, subdistant, short, whitish to yellowish. Stipe 30-45 x 14-35 mm, subcylindric to ventricose; surface tomentose, concolorous with the pileus surface. Context yellowish to yellowish white; odor of chlorine; taste not observed. Latex white, staining yellowish when exposed.

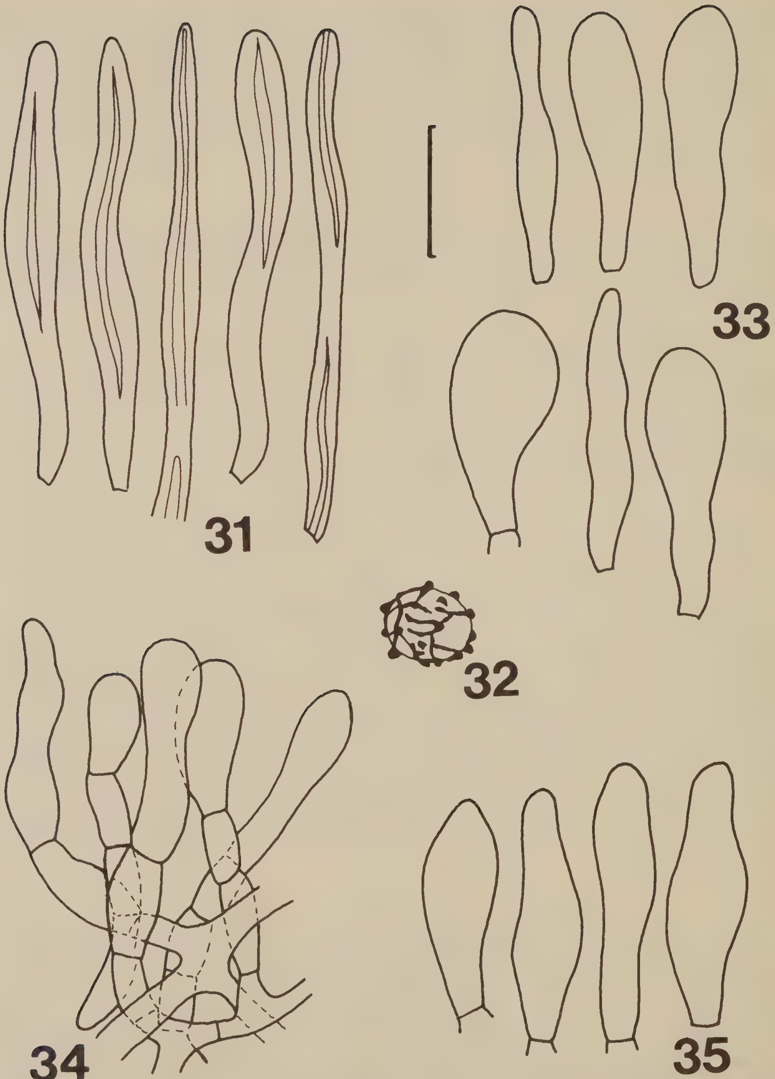
Spores 8-8.8 x 5.6-6.6 (-7.2) µm, elliptic, hilar appendage 0.8-1.6 µm high, hyaline; ornamentation amyloid of small and fine warts, up to 0.5 µm high, sometimes forming an incomplete reticulum. Basidia 58-65 x 10-12 µm, 1- to 4-spored, clavate, hyaline. Pleurocystidia 49.6-56 x 5.6-8 µm, subcylindric or subfusoid, mucronate or submucronate, some constricted in the apex, yellowish, with refringent contents. Cheilocystidia 40-58 x 4-8 µm, similar to pleurocystidia, with refringent contents. Pileus cuticle with pileocystidia 55-145 (-170) x (2.4-) 3-7 µm, cylindric to subfusoid, hyaline to yellowish, thick walled (walls 1-3 µm thick), subtending a cuticle of interwoven hyphae 3-6 µm diam. Context hyphae 5-7 µm diam.; sphaerocysts 15-33 x 15-25 µm; laticifers 5-15 µm diam., more or less numerous. Hymenophoral trama irregular, hyphae 5-15 µm diam., cylindric, hyaline to yellowish.

HABITAT. In soil, gregarious in a subtropical (mesophytic) forest and a disturbed tropical rain forest, at 530-1740 m alt., collected in May and September.

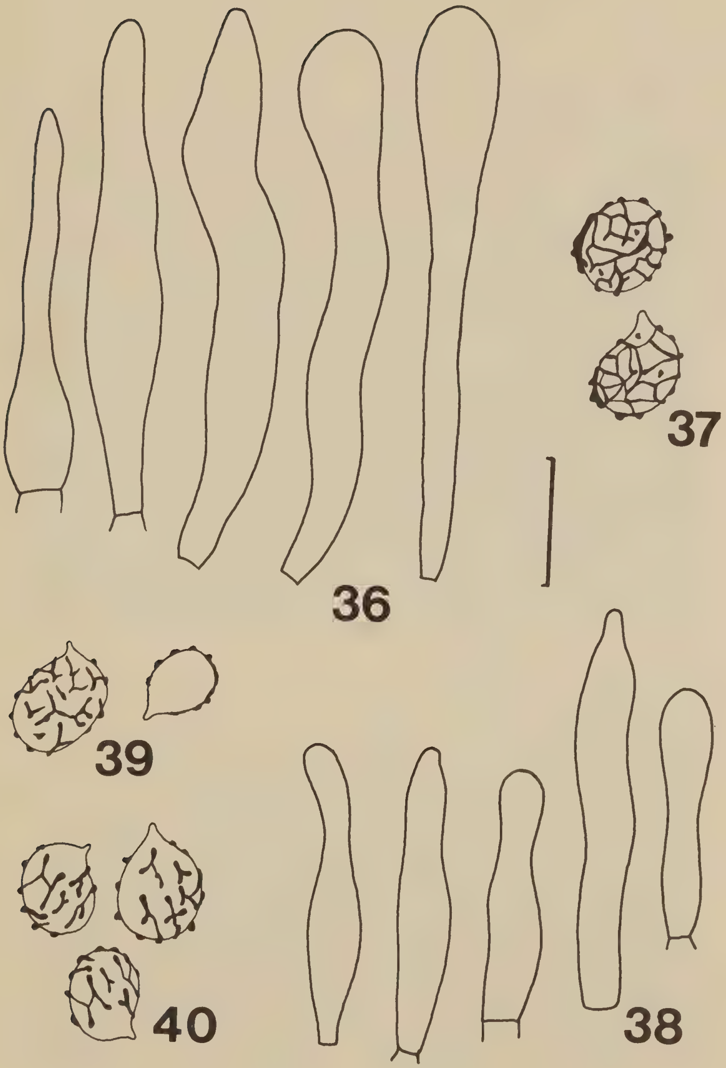
SPECIMENS EXAMINED: CHIAPAS, Tuxtla Gutiérrez, Jardín Botánico Faustino Miranda, Guzmán 29546 (XAL). VERACRUZ, Municipio Rafael Lucio, 9 km NE of Xalapa, road from Xalapa to La Joya, Granja Santa Barbara, Sampieri 851 (XAL).

DISCUSSION. The studied materials agree with the description in Hesler & Smith (1979). A closely related species, *L. vellereus* (Fr.) Fr. commonly occurs in coniferous and *Quercus* forests in Mexico, but differs from *L. subvellereus* var. *subdistans* by its wider spores (6.5-8.5 µm diam., Hesler & Smith, 1979; 12 µm, Herrera & Guzmán, 1961). *L. vellereus* was reported from Mexico by Herrera & Guzmán (1961), Guzmán (1961, 1977), Welden & Guzmán (1978), Guzmán-Dávalos & Guzmán (1979), Frutis & Guzmán (1983) and others as noted in Table 1. However, several of the materials reported as *L. vellereus* probably correspond to *L. subvellereus*.

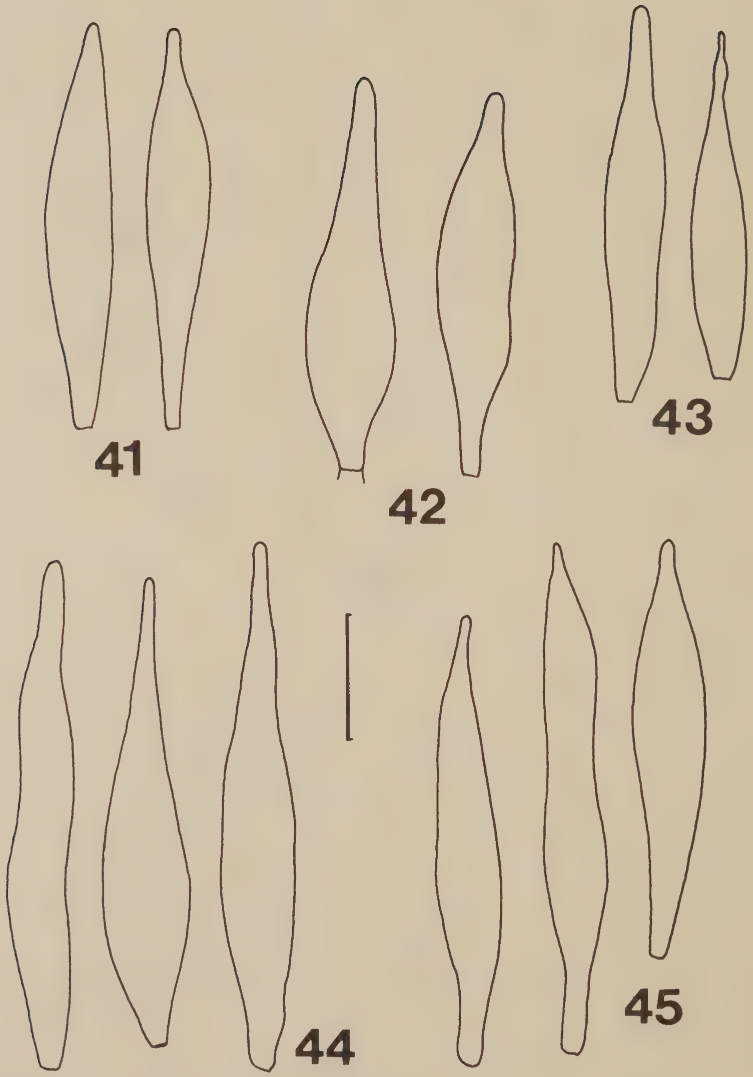
It is interesting that Hesler and Smith (1979) considered *L. subvellereus* var. *subdistants* as a northern fungus in U.S.A., while the typical variety southern, but Mexican collections from tropical and subtropical forests apparently proof a southern distribution of var. *subdistans*. This is the first record of *L. subvellereus* var. *subdistans* from Mexico.



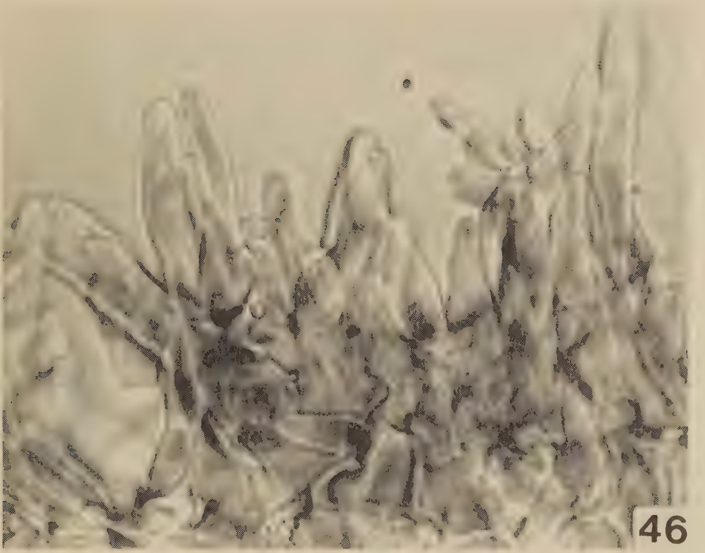
Figs. 31-35.- 31: *Lactarius subvellereus* var. *subdistans*, elements of the pileus cuticle. 32-35: *L. fuliginellus*, 32: spores, 33: cheilocystidia, 34: pileus cuticle, 35: elements of the pileus cuticle (31: Sampieri 851, 32-35: Montoya 767) (31, 35: bar= 16 µm; 32: bar= 10 µm; 33: bar= 15 µm; 34: bar= 20 µm).



Figs. 36-40.- 36: *Lactarius fuliginellus*, caulocystidia. 37-38: *Lactarius gerardii* var. *gerardii*, 37: spores, 38: cheilocystidia. 39-40: *L. uvidus*, spores (36: Montoya 767; 37, 38: Medel 172; 39: Sampieri 386; 40: Ventura 5965) (36: bar= 13 µm; 37, 39, 40: bar= 10 µm; 38: bar= 12 µm).



Figs. 41-45: *Lactarius uvidus*, 41-43: cheilocystidia, 44-45: pleurocystidia (41, 45: Ventura 5965; 43, 44: Sampieri 386; 42: Garcia 390) (41-45: bar= 17 µm).



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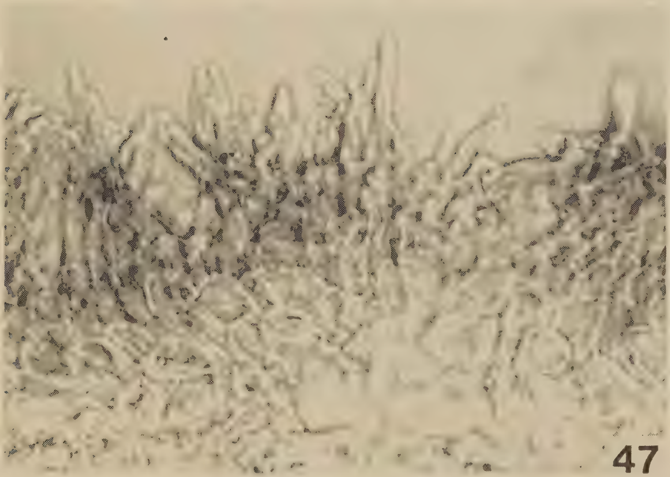


47

Figs. 46-47.- *Lactarius gerardii* var. *gerardii*, pileus cuticle, x 400 and x 160, respectively.

NEW LOCALITIES OF SPECIES PREVIOUSLY REPORTED FROM MEXICO

10. *Lactarius deceptivus* Peck, Ann. Rep. N. Y. State Mus. 38:125, 1885 var *deceptivus*

The relevant features that distinguish this species are the whitish color of the basidiocarp, sometimes staining yellowish-brown; pileus margin with a membranose veil; subelliptic spores 8.8-12 (-13.6) x 7.2-10.4 µm; pleurocystidia 56-64 x 5.6-8 µm, and cheilocystidia 40-52 (-60) x 4.8-7.2 µm.

This fungus was recorded from Mexico (Guzmán, 1977; Guzmán-Dávalos & Guzmán, 1979, León & Guzmán, 1980 and Zarco 1986). In this paper it is recorded from new localities of the State of Puebla: 3 km before Teziutlán, Cerro de Techacapa, Montoya 1593 (XAL) and from Veracruz: Municipio Acajete, La Joya, Ventura 17497 (XAL) from *Quercus* and from *Pinus* forests at 2050-2070 m alt., collected in July and September.

11. *Lactarius fuliginellus* A. H. Sm. & Hesler, Brittonia 14: 432, 1962

Figs. 32-36

This species is distinguished by the white latex which changes to pink, and the sizes of the cheilocystidia, pileocystidia and caulocystidia, 25-33 x 4-12 (-13) µm, 15-36 x 4-13 µm and 25-60 x 7-12 µm, respectively. Guevara et al. (1987) reported this species from Nuevo León. It is reported here in mesophytic forest at 1650 m alt., from the State of Veracruz: Municipio Rafael Lucio, 9 km NE of Xalapa, road from Xalapa to La Joya, Granja Santa Barbara, Montoya 767, collected in August (XAL).

12. *Lactarius gerardii* Peck, Bull. Buffalo Soc. Nat. Sci. 1: 57, 1873 var. *gerardii*

Figs. 37-39 and 46-47

The subdistant to distant lamellae, unchanging latex, spore size (8-10 x 7-9 µm), low ornamentations (0.5-1 µm high) and pileus cuticle consisting of 3-4 layers of cellular elements with pileocystidia of 14-40 x 3-8 µm, distinguish this fungus. It differs from var. *subrubescens* in which the lamellae and context turn red when bruised or cut, and from var. *fagicola* in which the lamellae and context change to brown or violaceous brown.

Guevara et al. (1987) recorded this variety from Tamaulipas and Veracruz (from La Calavera, Municipio Atzalan, in the last State). The materials studied here are recorded from 5 new localities in the State of Veracruz, in mesophytic forests at 1300-1680 m alt., fruiting during May-October.

Veracruz: km 2.5 old road from Xalapa to Coatepec, Parque Ecológico Francisco J. Clavijero, Brown 147, 448; Sampieri 437 (all in XAL). 1st. Mushroom Exposition of INIREB, Guzmán 23212 (XAL). Municipio Banderilla, Cerro La Martinica, Chacón 1534; García 361 (all in XAL). Municipio Naolinco, Ventura 13059 (ENCB). Municipio San Andrés Tlalnehuayocan, San Antonio, Ventura 13310 (ENCB). Municipio Rafael Lucio, 9 km NE of Xalapa, road from Xalapa to La Joya, Granja Santa Barbara, Medel 172 (XAL).

13. *Lactarius hygrophoroides* Berk. & Curt., Ann. Mag. Nat. Hist., 3rd ser., 4: 293, 1859 var. *hygrophoroides*

Basidiocarps in this species present a velvety surface, orange to yellowish orange color (cinnamon 15'' to umber 15'i) or brownish orange (dark umber 15i) in young specimens, spores 8-9.6 x 5.6-8 µm, with a partial reticulum up to 0.8 µm high.

Guevara et al. (1987) recorded this fungus from the States of Tamaulipas and Veracruz. In the present paper is recorded from Mesophytic and *Pinus-Quercus* forests, at 1340-1700 m alt., from

Baja California Sur: El Cabo Region, Sierra de La Laguna, León de la Luz 75 and from new localities of the State of Veracruz: near Xalapa (1st. Mushroom Exposition of INIREB), Guzmán 23213; 2 km SW from Xalapa, near the Coapexpan river, Montoya 776, 1263 (all in XAL). The specimens were collected during July-October.

14. *Lactarius uvidus* (Fr. : Fr.) Fr., Epicr. Syst. Mycol. p. 338, 1838 var. *uvidus*

Figs. 39-45 and 48

This species is characterized by the violaceous staining of the basidiocarps due to the oxidation of the white latex, azonated or diffusely zonate pileus surface, which is violaceous brown or greyish brown, the whitish or yellowish lamellae, the abundant cystidia [pleurocystidia (38-) 40-95 (-123) x 7-12 µm, cheilocystidia 35-72 x 7-12 µm], gelatinized pileus cuticle with no hyphal incrustations, and spore size (7-) 8-12 (-13) x (6-) 7-9 µm. Pérez-Silva and Aguirre-Acosta (1985; 1986) recorded this fungus from the States of Durango and Chihuahua. In the present paper the distribution is extended to the States of Guerrero, Hidalgo and Veracruz:

GUERRERO: Municipio Chilpancingo, Omiltemi, road to the stream Agua Fría, Villegas 371 (FCME). HIDALGO: 5 km to SW of Huasca, near the deviation to Atotonilco, Guzmán 8243 (ENCB). VERACRUZ: Municipio Altotonga, Zoatzingo, Sampieri 386 (XAL). Municipio Las Vigas, N of Cofre de Perote Region, road from las Vigas to El Llanillo, López 1488 (XAL). Las Vigas, Ventura 5965 (ENCB). Road to Tembladeras, Presa Alto Pixquiac, García 390 (XAL). Municipio Xico, E of Cofre de Perote Region, S of Tembladeras, Ejido Ingenio El Rosario, Guzmán 28862 (XAL).

These localities are in *Pinus*, *Pinus-Quercus* or *Pinus-Abies* forests, at 2040-2920 m alt; the collections were made during July-October.

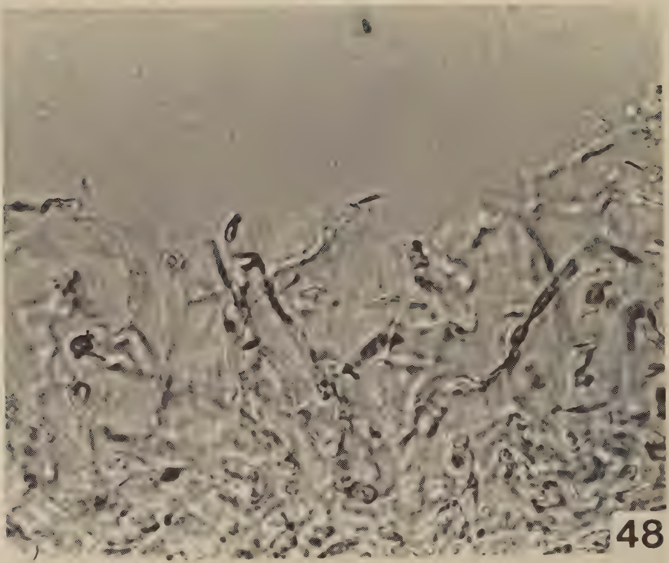
DISTRIBUTION OF KNOWN SPECIES OF *LACTARIUS* IN MEXICO

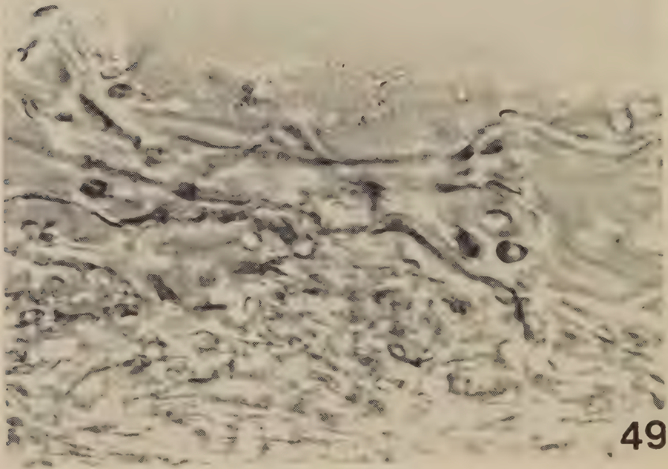
A total of 45 known species of *Lactarius* have been reported from Mexico, including the 9 species and varieties described in this paper. This is a very low number, since these fungi are widely distributed in Mexico and there are a large number of species in other areas of the world. Singer (1986) considered 122 species, Hawksworth et al. (1983) 120 species and Hesler and Smith (1979) 260 species. Many more species are expected to be found in Mexico.

The genus *Lactarius* is widespread in coniferous and temperate woods, where most of the Mexican species have been collected. However, there also are tropical species of which only *L. veraecrucis* Sing., *L. neotropicus* Sing., and *L. subvellereus* var. *subdistans* have been reported; the latter species also from a subtropical forest. *L. veraecrucis* has been reported from the State of Veracruz (Singer, 1973) and is probably a synonym of *L. venezuelanus* Dennis from Venezuela, as Guzmán (1977; 1986) noted. *L. neotropicus* was reported from the Peninsula of Yucatan in the State of Quintana Roo by Guzmán (1983).

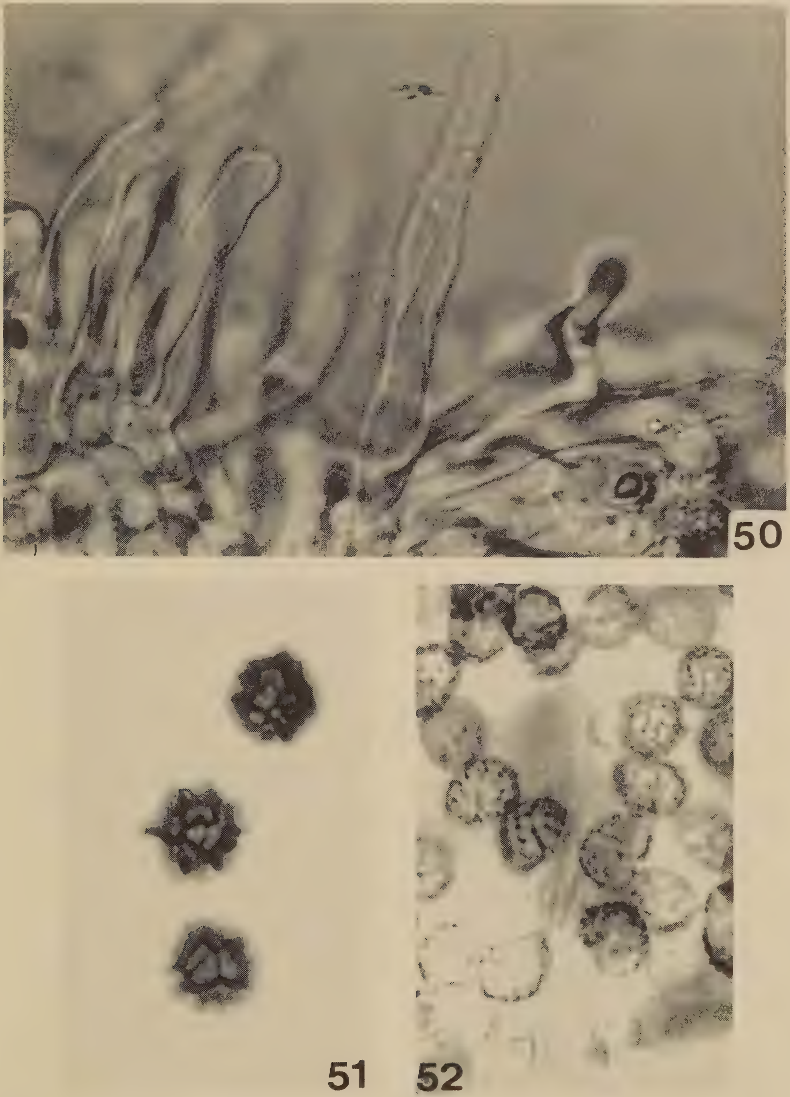
The known species of *Lactarius* in Mexico are distributed in 22 States, ranging from Baja California, Chihuahua and Tamaulipas in the north to Yucatan in the southeast. Table 1 presents all the known *Lactarius* taxa from Mexico (45 species and varieties) and is based on 75 bibliographic references (Table 2).

The most common species appear to be *L. chrysorheus*, *L. deliciosus*, *L. indigo*, *L. piperatus*, *L. rufus*, *L. salmonicolor*, *L. scrobiculatus*, *L. torminosus* and *L. zonarius*, all of which were reported by Guzmán (1977).





Figs. 48-49.- Pileus cuticle. 48: *Lactarius uvidus* var. *uvidus*, x 160. 49: *L. lacunarum*, x 160.



Figs. 50-52.- 50: *Lactarius eburneus* var. *ervinii*, pileus cuticle. 51: *L. subplinthogalus*, spores. 52: *L. subvellereus* var. *subdistans*, spores. All x 400.

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Table 1. SPECIES AND VARIETIES OF *LACTARIUS* REPORTED FROM MEXICO (the numbers refer to the bibliographic references of Table 2)

Lactarius argillaceifolius Hesler & A. H. Sm.	TAMAULIPAS (70)
L. camphoratus (Bull. : Fr.) Fr.	BAJA CALIFORNIA NORTE (51) ESTADO DE MEXICO (58) MORELOS (60) NUEVO LEON (36) UNPRECISE LOCALITY (31,72)
L. chrysorheus Fr.	CHIHUAHUA (65) DURANGO (57, 61) HIDALGO (38, 45) JALISCO (30, 33, 54) MORELOS (60) NUEVO LEON (36) VERACRUZ (34, 40, 56) ZACATECAS (49) UNPRECISE LOCALITY (31,72)
* *L. deceptivus* Peck var. *deceptivus*	PUEBLA VERACRUZ (37,40) UNPRECISE LOCALITY (31,72)
L. deliciosus (L.: Fr.) S. F. Gray	CHIHUAHUA (65) DISTRITO FEDERAL (1, 6, 9, 11, 17, 53) DURANGO (57, 61) ESTADO DE MEXICO (1, 8, 9, 10, 13, 15, 17, 18, 19, 20, 25, 53) HIDALGO (17, 38,

Cont. Table 1.

		45) JALISCO (26, 30,32, 54) MICHOACAN (17, 43, 74) MORELOS (60) NUEVO LEON (36, 63) OAXACA (8) PUEBLA (28, 47) SAN LUIS POTOSI (17) TAMAULIPAS (75) VERACRUZ (34, 37, 40, 56, 62, 67, 68, 71) UNPRECISE LOCALITY (7, 21, 31, 32, 72)
*	*L. eburneus* var. *ervinii* & Hesler A. H. Sm.	VERACRUZ
*	*L. fragilis* (Burl.) Hesler & A. H. Sm.	VERACRUZ
*	*L. fuliginellus* A.H. Sm. & Hesler	NUEVO LEON (70) VERACRUZ
	L. fuliginosus Bull. : Fr.	OAXACA (8)
	L. fumosus Peck	DURANGO (70) TAMAULIPAS (70)
*	*L. gerardii* Peck var. *gerardii*	TAMAULIPAS (70) VERACRUZ (70)
*	*L. gerardii* var. *fagicola* (A. H. Sm. & Hesler) Hesler & A. H. Sm.	VERACRUZ

382	25	for	*glauscecens*	read	*glaucescens*
451	35	*for*	protracta	read	*protractum*
452	21	*for*	protracta	read	*protractum*
453	13	*for*	protracta	read	*protractum*

Cont. Table 1.

* *L. gerardii* var. *subrubescens* (A. H. Sm. & Hesler) Hesler & A. H. Sm.	VERACRUZ
* *L. hygrophoroides* Berk. & Curt.	CHIAPAS (52) TAMAULIPAS (70) VERACRUZ (70) BAJA CALIFORNIA SUR
L. indigo Fr.	BAJA CALIFORNIA NORTE (51) CHIHUAHUA (65) DISTRITO FEDERAL (6, 8) DURANGO (61) ESTADO DE MEXICO (8, 19, 69) HIDALGO (38, 45) JALISCO (26,30,33,54,73) MICHOACAN (41, 42, 43, 74) MORELOS (17, 60 NUEVO LEON (36, 59, 63) OAXACA (8, 17, 48) PUEBLA (2, 14, 47) TAMAULIPAS (75) VERACRUZ (34, 40) ZACATECAS (49) UNPRECISE LOCALITY (3, 4, 31, 32, 35, 72)
L. insulsus Fr.	NUEVO LEON (36, 59, 63)
* *L. lacunarum* (Romagn.) Hora	VERACRUZ
* *L. lignyotellus* A. H. Sm. & Hesler	VERACRUZ

SEE ERRATA

Cont. Table 1.

"*L. lignyotellus* cf. *texensis* A. H. Sm. & Hesler"	DURANGO (70)
L. mitissimus Fr.	ESTADO DE MEXICO (20)
L. neotropicus Sing.	YUCATAN (46, 64)
L. olympianus Hesler & A. H. Sm.	NUEVO LEON (70) TAMAULIPAS (70)
L. pallidus (Pers. : Fr.) Fr.	CHIHUAHUA (65)
L. peckii (Burl.) Sacc.	UNPRECISE LOCALITY (4, 7)
L. piperatus (L. : Fr.) S. F. Gray	CHIAPAS (12) ESTADO DE MEXICO (12, 44) HIDALGO (38, 45) JALISCO (55) MORELOS (12, 60) OAXACA (12) VERACRUZ (34, 40) UNPRECISE LOCALITY (31,72)
L. piperatus var. *glauscecens* (Crossl.) Hesler & A. H. Sm.	TAMAULIPAS (70)
L. quietus Fr.	DURANGO (61)
L. representaneus Britz.	PUEBLA (47)
L. rufus (Scop. : Fr.) Fr.	DISTRITO FEDERAL (16) DURANGO (61) ESTADO DE MEXICO (15, 16, 18) HIDALGO (45)

Cont. Table 1.

	MICHOACAN (43) MORELOS (60) VERACRUZ (34, 40, 56) UNPRECISE LOCALITY (24, 31, 32, 72)
L. rugatus Kuhner & Romagn.	CHIHUAHUA (65)
L. salmonicolor Heim & Leclair	CHIHUAHUA (65) DURANGO (61) ESTADO DE MEXICO (5, 8, 14, 15, 17, 18, 20, 44) HIDALGO (45) MICHOACAN (41, 42, 43, 74) MORELOS (60) VERACRUZ (40, 56, 62, 67, 71) UNPRECISE LOCALITY (31, 32, 72)
L. sanguifluus Paul. : Fr.	HIDALGO (45) JALISCO (30, 33, 54) VERACRUZ (34, 40) UNPRECISE LOCALITY (31, 32, 72)
L. scrobiculatus (Scop. : Fr.) Fr.	BAJA CALIFORNIA NORTE (51) DURANGO (61) ESTADO DE MEXICO (8, 14, 15, 18, 20) GUANAJUATO (24) HIDALGO (38, 45) MICHOACAN (41, 42, 43, 74) PUEBLA (47) UNPRECISE LOCALITY (22, 31, 72)

Cont. Table 1.

	L. speciosus Burl.	NUEVO LEON (70)
	L. subdulcis (Bull. : Fr.) S.F. Gray	MORELOS (39) HIDALGO (45) NUEVO LEON (59, 63) VERACRUZ (34, 40) UNPRECISE LOCALITY (31, 72)
*	*L. sublacustris* Hesler & A. H. Sm.	VERACRUZ
*	*L. subplinthogalus* Coker	VERACRUZ
*	*L. subvellereus* var. *subdistans* Hesler & A. H. Sm.	VERACRUZ CHIAPAS
	L. tabidus Fr.	MORELOS (60) UNPRECISE LOCALITY (31, 72)
	L. torminosus (Schaeff. : Fr.) S. F. Gray	CHIHUAHUA (65) DURANGO (57, 61) ESTADO DE MEXICO (16) HIDALGO (45) JALISCO (26, 30, 33, 54) MICHOACAN (43, 74) MORELOS (16, 60) UNPRECISE LOCALITY (25, 31, 72)
*	*L. uvidus* (Fr. : Fr.) Fr. var. *uvidus*	CHIHUAHUA (65) DURANGO (61) GUERRERO HIDALGO VERACRUZ
	L. vellereus (Fr.) Fr.	CHIAPAS (12) ESTADO DE MEXICO

Cont. Table 1.

	(12, 16, 17, 50) HIDALGO (38, 45) MICHOACAN (43) MORELOS (12, 60) OAXACA (12, 16, 17) PUEBLA (28, 47) VERACRUZ (34, 37, 40) UNPRECISE LOCALITY (31, 72)
L. veraecrucis Sing.	HIDALGO (38) VERACRUZ (27, 29, 34, 37, 40, 48, 64) UNPRECISE LOCALITY (31, 66)
L. volemus (Fr.) Fr.	HIDALGO (38, 45) NUEVO LEON (59, 63) MICHOACAN (74) UNPRECISE LOCALITY (31)
L. zonarius (Bull. : St. A.) Fr.	BAJA CALIFORNIA NORTE (51) CHIHUAHUA (65) HIDALGO (45) MICHOACAN (43) MORELOS (39) VERACRUZ (40) ZACATECAS (49) UNPRECISE LOCALITY (31,72)

* New records or new localities from Mexico described in this paper.

Table 2. BIBLIOGRAPHIC REFERENCES ON *LACTARIUS* FROM MEXICO IN CHRONOLOGICAL ORDER (the numbers of the references correspond to those of Table 1)

1.- Gándara (1929-1931)
2.- Sharp (1945)
3.- Sharp (1946)
4.- Sharp (1948)
5.- Heim (1953)
6.- Cravioto et al. (1951)
7.- Zenteno et al. (1955)
8.- Singer (1957)
9.- Guzmán (1958a)
10.- Guzmán (1958b)
11.- O. Sánchez (1958)
12.- Heim (1959)
13.- Pérez-Silva (1959)
14.- Hesler & Smith (1960)
15.- González & Sánchez (1961)
16.- Guzmán (1961)
17.- Herrera & Guzmán (1961)
18.- Sánchez-León (1961)
19.- Dubovoy et al. (1966)
20.- Guzmán (1966)
21.- Martín del Campo (1968)
22.- Guzmán (1969)
23.- Pérez-Silva (1969)
24.- Pérez-Silva et al. (1970)
25.- Valdez-Ramírez (1972)
26.- Guzmán & García-Saucedo (1973)
27.- Singer (1973)
28.- Guzmán et al. (1975)
29.- Singer (1975)
30.- Manzi (1976)
31.- Guzmán (1977)
32.- Guzmán (1978)
33.- Manzi (1978)
34.- Welden & Guzmán (1978)
35.- Hongo & Yokoyama (1978)
36.- Castillo et al. (1979)
37.- Guzmán-Dávalos & Guzmán (1979)
38.- Varela y Cifuentes (1979)
39.- De Avila et al. (1980)
40.- León & Guzmán (1980)
41.- R. Sánchez (1980 a)
42.- R. Sánchez (1980 b)

Cont. Table 2.

43.- Mapes et al. (1981)
44.- González (1982)
45.- Frutis & Guzmán (1983)
46.- Guzmán (1983)
47.- Martínez-Alfaro et al. (1983)
48.- Singer et al. (1983)
49.- Acosta & Guzmán (1984)
50.- Aroche et al. (1984)
51.- Ayala & Guzmán (1984)
52.- Chacón & Guzmán (1984)
53.- Gispert et al. (1984)
54.- Guzmán-Dávalos & Nieves (1984)
55.- Guzmán-Dávalos & Trujillo (1984)
56.- Guzmán & Villarreal (1984)
57.- Rodríguez-Scherzer & Guzmán-Dávalos (1984)
58.- Frutis-Molina et al. (1985)
59.- Garza et al. (1985)
60.- López et al. (1985)
61.- Pérez-Silva & Aguirre-Acosta (1985)
62.- Villarreal & Guzmán (1985)
63.- Garza (1986)
64.- Guzmán (1986)
65.- Pérez-Silva & Aguirre-Acosta (1986)
66.- Singer (1986)
67.- Villarreal & Guzmán (1986a)
68.- Villarreal & Guzmán (1986b)
69.- Estrada-Torres & Aroche (1987)
70.- Guevara et al. (1987)
71.- Villarreal (1987)
72.- Zarco (1986)
73.- Téllez et al. (1988)
74.- Díaz-Barriga et al. (1988)
75.- Heredia (1989)

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RUMINOMYCES ELEGANS GEN. ET SP. NOV., A POLYCENTRIC ANAEROBIC RUMEN FUNGUS FROM CATTLE

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ABSTRACT

Ruminomyces elegans gen. et sp. nov., a polycentric anaerobic fungus from the rumen of cattle is described and illustrated. The fungus produces rhizomycelium which develops unbranched, solitary sporangiophores with ellipsoidal to fusiform sporangia. Zoospores are monoflagellate.

Since the discovery of the anaerobic fungi in the rumen of sheep (Orpin, 1975) and cattle (Bauchop, 1979), four monocentric species, viz., **Neocallimastix frontalis** (Braune) Heath (Heath, **et al.**, 1983), **N. patriciarum** Orpin & Munn (1986), **Caecomyces equi** Gold (Gold **et al.**, 1988) and **Piromyces communis** Gold (Gold **et al.**, 1988) have been formally described and assigned their taxonomic positions. These fungi, all with monocentric development, usually produce thalli possessing a single sporangium and anucleate rhizoids.

Recently, the genus **Orpinomyces** was erected by Barr **et al.** (1989) to accomodate a polycentric species **O. bovis** Barr & Kudo isolated from the rumen of a Holstein steer in

Canada. This species produces an extensive and complex nucleate rhizomycelium from which numerous globose sporangia developed. Zoospores are polyflagellate.

A recent isolation of fungi from the rumen of a Hereford steer (**Bos taurus**) fed oaten chaff once daily, at the University of New England, Armidale, Australia, yielded a fungus with polycentric development and producing sporangia with monoflagellate zoospores. Since no appropriate genus already described seems available for this fungus, it is, therefore, decided to make it the type of a new genus.

Ruminomyces Ho gen. nov.

Rhizomycelium complexus, polycentricum. Hyphae ramosissimae, aliquot latae plerumque constrictae, ceterus tenuis et radices similis. Sporangiophora erecta, solitaria, simplicia ex hypis terminali et laterali orientia. Sporangia solitaria, late-ellipsoideae ad fusiformae, plerumque apice acuminatis. Zoospora globosa ad formis variantis, flagella uno. Semper anaerobiae.

Species typica: **Ruminomyces elegans.**

Rhizomycelium complex, polycentric. Hyphae much-branched, large, often with constrictions, or fine and root-like. Sporangiophore erect, solitary, unbranched, arising laterally or terminally from the hyphae. Sporangia solitary, broadly ellipsoidal to fusiform, usually with an acuminate apex. Zoospore monoflagellate, spherical to variable in shape. Obligate anaerobe.

Ruminomyces elegans Ho sp. nov. Figs. 1 - 3.

Rhizomycelium complexus, polycentricum. Hyphae ramosissimae, aliquot latae, 2.5 - 10 µm crassae, plerumque constrictae, ceterus tenuis, 0.5 - 2 µm crassae, et radices similis. Sporangiophora erecta, solitaria, simplicia, 2 - 10 µm lata, ex hypis terminali et laterali orientia. Sporangia solitaria, late-ellipsoideae ad fusiformae, 40 - 125 µm longae et 14 - 55 µm latae, plerumque apice acuminatis, 2.5 - 16 µm longae et 2 - 3 µm latae, tunicus laevigatis, hyalinae ad subhyalinae. Zoospora globosa, 6.5 - 9.0 µm diametro, ad formis variantis, hyalinae ad subhyalinae, flagella uno, 24 - 33 µm longae. Semper anaerobiae.

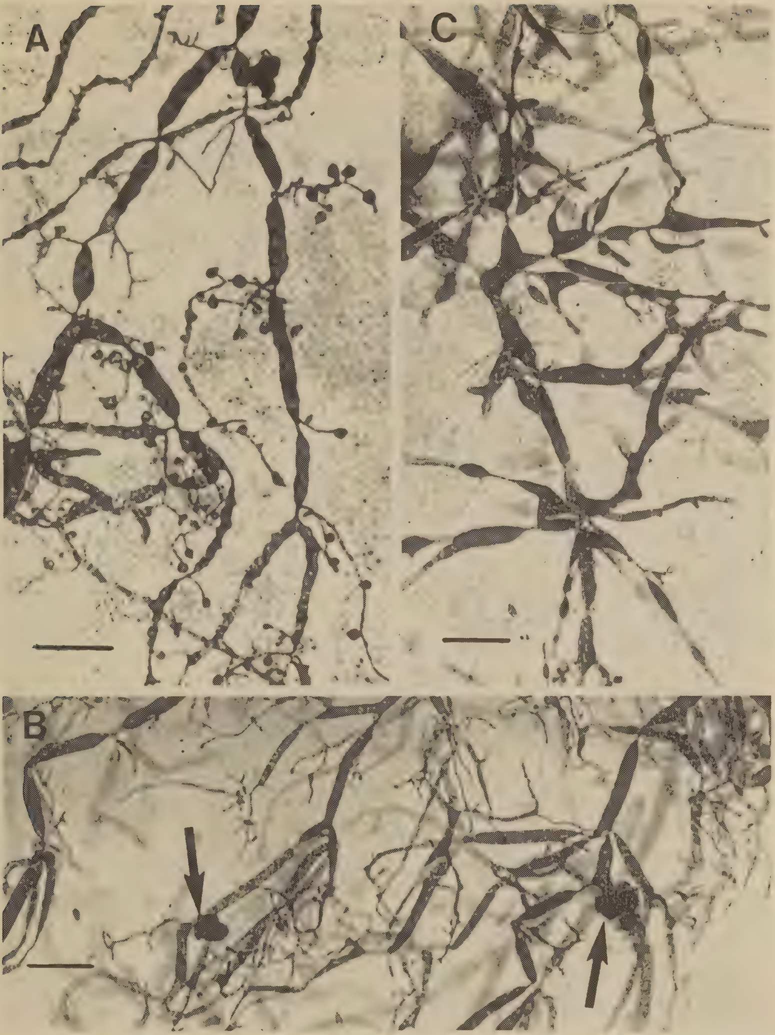

Fig. 1. **Ruminomyces elegans.** A, wide and narrow hyphae. Note the sausage-shaped hyphae with constrictions at regular and irregular intervals and lobed or bead-like structures on the narrow hyphae; B, large, lobed structures (arrows) on the wide hyphae; C, branching of hyphae. Grown in medium with ball-milled filter paper. Stained with lactophenol cotton-blue. Bar = 20 μm.

In digesta particles and fluid from rumen of Hereford cattle, University of New England, Armidale, Australia, 5 April, 1989, Y.W. Ho & T. Bauchop C2 (UPM), holotypus.

It is proposed that this new genus be placed in the family Neocallimasticaceae, which has been expanded by Barr **et al.**, (1989) to include the polycentric species, and the family to be in the order Spizellomycetales.

The rhizomycelium of **R. elegans** is composed of much-branched, narrow to wide hyphae ranging from 0.5 - 10 µm wide. Many of the wide hyphae are sausage-shaped with constrictions at regular and irregular intervals (Figs. 1A-C). Some of the constrictions are long and drawn-out whilst others are short. Occasionally, some hyphae break off at the constrictions, but more commonly, new branches (both wide and narrow), develop from the constrictions. Some hyphae also produce lobed or bead-like structures, 1.5 - 14.5 µm wide x 1.5 - 12.5 µm high. Frequently, fine pegs (about 0.5 µm wide) are produced from the centre of these lobed or bead-like structures. The characteristics of these structures appear to be similar to the "appressoria" produced by anaerobic fungi colonising grass and straw fragments in the rumen of cattle and swamp buffalo (Ho **et al.**, 1988a).

Sporangiophores arise laterally (Fig. 2A) or terminally (Fig. 2B) from the sausage-shaped hyphae. They are solitary, erect, straight to slightly flexuous, mostly unbranched, 2 - 10 µm wide x 25 - 100 µm long, occasionally with 1 - 2 very short, peg-like branches at the base (Fig. 2A), broadening slightly above, smooth-walled, hyaline to subhyaline. Each sporangiophore produces a single sporangium at its apex. The sporangiophores of **R. elegans** are distinctly different from those of **O. bovis.** They are solitary, simple, unbranched and more or less uniform in width, whereas those of **O. bovis** are irregularly branched, of uneven width, some with constrictions, and more than one sporangia may develop on the sporangiophore (Barr **et al.**, 1989).

The sporangium develops singly on the sporangiophore. It starts as a swollen structure at the apex of the sporangiophore, becoming globose, ellipsoidal to fusiform as it develops. Large, mature sporangia are usually broadly ellipsoidal to fusiform, 40 - 125 µm long x 14- 55 µm wide with acuminate apices, 2.5 - 16 µm long x 2 - 3 µm

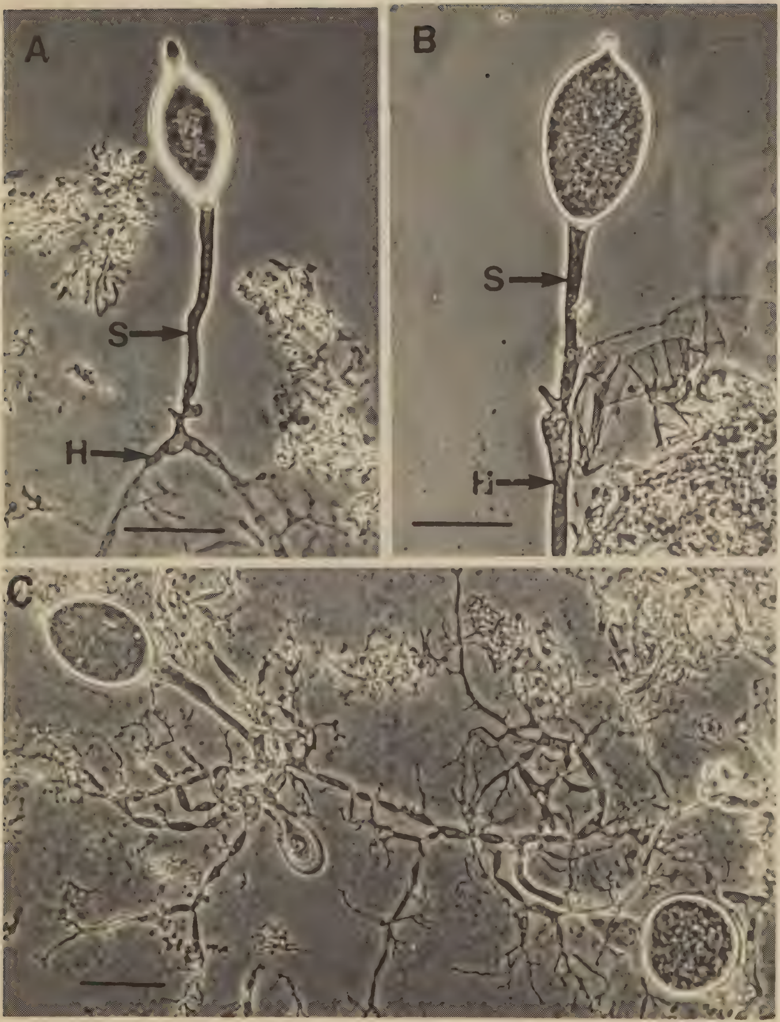

Fig. 2. **Ruminomyces elegans**. A-B, sporangiophores with sporangia; C, rhizomycelium with 3 young sporangia of different shapes. S, sporangiophore; H, hypha. Grown in medium with ball-milled filter paper. Bar = 40 μm.

wide, rarely spherical, but young sporangia occasionally are spherical (Figs. 2A-C). A septum at the base of the sporangium separates it from the sporangiophore. The sporangium is smooth-walled, hyaline to subhyaline.

In culture, abundant zoosporogenesis occurs in medium with ball-milled Whatman No. 1 filter paper, but differentiation and liberation of zoospores will only take place when thalli with sporangia at the correct stage of development are transferred to fresh medium.

Mature zoospores are apparently released through a transverse slit around the middle of the sporangium as empty sporangia with transverse slits have been observed (Fig. 3C).

Newly-released zoospores are actively motile, moving in an erratic manner with the single flagellum, 24 - 33 µm long, posteriorly orientated. The cell of the zoospore is usually spherical, 6.5 - 9 µm diameter, sometimes variable in shape, hyaline to subhyaline with granular contents and appearing highly refractile when viewed by phase-contrast microscopy (Figs. 3C-D). Zoospores are actively motile for 1 to 2 h after release, then the zoospore ceases movement and the flagellum detaches. Germination soon follows. Occasionally, the flagellum remains attached to the germinating zoospore.

Although this fungus is also a polycentric species, the salient differences in the morphology of the hyphae, sporangiophore, sporangium and zoospore separate it distinctly from **O. bovis** and thus requires the erection of a new genus to accomodate it.

Other isolates examined: One other isolate obtained from the rumen contents of cattle at the University of New England, Armidale, Australia, March 1989, and 9 isolates obtained from the rumen contents of cattle (**Bos indicus**) and swamp buffalo (**Bubalus bubalis**) at Universiti Pertanian Malaysia, Serdang, Malaysia, August-October, 1987, were also examined and their characteristics conform to the above describtion.

Anaerobic rumen fungi with fusiform sporangia have been reported to occur in cattle in New Zealand (Bauchop, 1979), in USA (Akin and Rigsby, 1987), in cattle and water

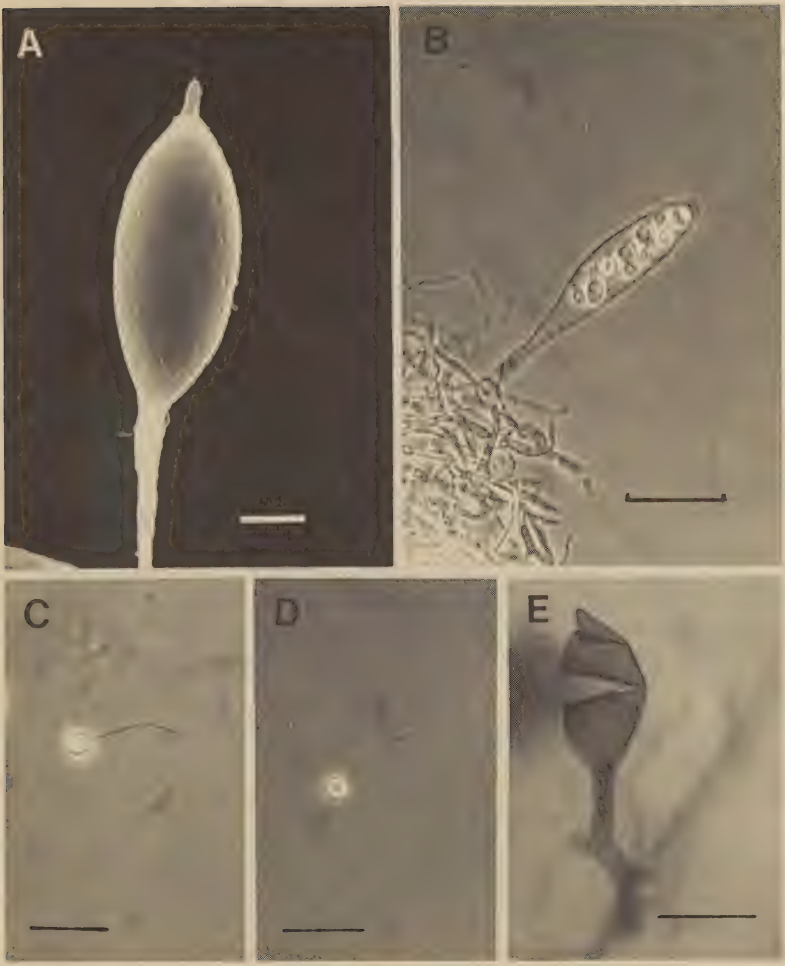

Fig. 3. **Ruminomyces elegans**. A, scanning electron micrograph of a sporangium, Bar = 10 µm ; B, a mature sporangium with zoospores, Bar = 40 µm ; C–D, monoflagellate zoospores, Bar = 20 µm; E, an empty sporangium with a transverse slit around the middle of the sporangium, stained with lactophenol cotton-blue, Bar = 40 µm. Cultures grown in medium with ball-milled filter paper.

buffalo in Malaysia (Ho **et al.**, 1988b), and in Australia (Phillips, 1988).

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SEVERAL NOTEWORTHY HIGHER FUNGI FROM SOUTHERN YUNNAN, CHINA

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Abstract

Being interesting taxonomically or geographically, twelve species of higher fungi occurring in southern Yunnan, China are reported in this paper, of which eleven species are new to China, viz. *Cookeina indica* Pfister et Kaushal, *Lamprospora lobata* (Berk. et Curt.) Seaver, *Ramaria capucina* (Pat.) Petersen, *Cyptotrama asprata* (Berk.) Redhead et Ginns, *Favolaschia tonkinensis* (Pat.) Singer, *Lepiota ianthinosquamosa* Pegler, *Lepiota phaeosticta* Morgan, *Lepiota phlyctaenodes* (Berk. et Br.) Sacc., *Lepiota subincarnata* J. Lange, *Leucocoprinus bresadolae* (Schulz.) Moser, and *Pterospora nigripes* (Schw.) Horak. All of the species are illustrated, and their distribution patterns are provided.

汉文摘要

本文报道产于中国滇南的12种高等真菌，其中11种为中国的新记录，它们是印度毛杯菌*Cookeina indica* Pfister et Kaushal，波皱齿盘菌*Lamprospora lobata* (Berk. et Curt.) Seaver，竹林枝瑚菌*Ramaria capucina* (Pat.) Petersen，粗干磨*Cyptotrama asprata* (Berk.) Redhead et Ginns，东京胶孔菌*Favolaschia tonkinensis* (Pat.) Singer，暗鳞环柄菇*Lepiota ianthinosquamosa* Pegler，暗斑环柄菇*Lepiota phaeosticta* Morgan，瘤鳞环柄菇 *Lepiota phlyctaenodes* (Berk. et Br.) Sacc.，近肉红环柄菇 *Lepiota subincarnata* J. Lange，褐环白鬼伞*Leucocoprinus bresadolae* (Schulz.) Moser 和黑柄翼孢菌*Pterospora nigripes* (Schw.) Horak. 每种均有分布及附图.

While studying the fungi collected from Xishuangbanna, southern Yunnan, the author has come across a number of species which are interesting taxonomically or geographically. Some of them are reported in this account. All specimens concerned are deposited in the Herbarium of Cryptogams at the Kunming Institute of Botany, Academia Sinica.

1. _Cookeina indica_ Pfister et Kaushal in Mycotaxon 20 (1): 117,1984.——— _Cookeina colensoi_ (Berk.) Seaver _sensu_ Teng, Fungi of China: 278, 1963. Fig. A
Specimens examined: Z. L. Yang* 254, 288, 289, 395 (HKAS 21449, 21450, 21451, 21452 respectively), on rotten woods in tropical forests.
Distr.: India, Southwest China.
Note: Seaver (1913) reported that the spores of _Cookeina colensoi_ (Berk.)Seavar have longitudinal striations,while Rifai (1968) and Denison (1967) stated that the spores of this species are smooth, and the latter also pointed out that many of the neotropical specimens in American herbaria labed "_C_. _colensoi_" are in fact _C_. _venezuelae_ (Cooke) Le Gal. _C_. _colensoi_ is chiefly confined to the Southern Hemisphere, in the tropics both of the Old World and of the New World (Rifai, 1968). Teng's _Cookeina colensoi_ is apparently _C_. _indica_, which may widely be distributed in tropical Asia.

2. _Lamprospora lobata_ (Berk. et Curt.) Seaver in Mycologia 6: 22, Pl. CXIV-12, 1914. ——— _Peziza lobata_ Berk. et Curt. in J. Linn. Soc., Bot. 10: 365, 1869. Fig. B
Specimen examined: Z. L. Yang 507 (HKAS 21466), on soil under a tropical seasonal rain forest.
Distr.: Cuba, Trinidad, Sri Lanka(?), India and

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* Z. L. Yang = Zhu-liang Yang

China (southern Yunan).
Note: Of larger (1-3.5 cm in diam.) and white apothecia, the above collection shares features of the Indian collection of this species (Thind and Waraitch, 1971).

3. Pterulicium xylogenum (Berk. et Br.) Corner in Ann. Bot. Mem. 1: 287, 1950. ——— Clavaria xylogena Berk. et Br. in J. Linn. Soc., Bot.14: 76, 1874. Fig. C
specimen examined: Z. L. Yang 683 (HKAS 22080), on rotten sheaths of bamboo shoots.
Distr.: Tropical Asia.
Note: This species, reported from Guangdong, China recently (Bi et al, 1985), is abundant under bamboo forests in Xishuangbanna during the rainy season.

4. Ramaria capucina (Pat.) Petersen in Bibl. Mycol. 79: 121, 1981. ——— Clavaria capucina Pat. in Bull. Soc. Mycol. Fr. 33: 50, 1917.
Fig. D
Specimen examined: Z. L. Yang 969 (HKAS 22079), on the ground under a tropical bamboo forest.
Distr.: Vietnam, and China (southern Yunnan).
Note: Our specimen has a little large spores, measuring 5.2-6.4 (7.0) X 3.2-4.3 (4.4) µm, as compared with what recorded by Petersen (1981).

5. Cyptotrama asprata (Berk.) Redhead et Ginns in Can. J. Bot. 58: 731, 1980. ——— Agaricus aspratus Berk. in Hook., London J. Bot. 6: 481 (bis), 1847. Fig. E
Specimen examined: Z. L. Yang 707 (HKAS 22136), on rotten woods.
Distr.: Pantropical.
Note: Widely distributed in tropical regions of the world, this species extends its range to the southeast part of Canada, with a distribution pattern similar to Xeromphalina tenuipes (Schw.) A. H. Smith (Redhead and Ginns, 1980).

6. Favolaschia tonkinensis (Pat.) Singer in Lloydia 8: 197, 1945. ——— Laschia tonkinensis Pat. in J. de Bot. 5: 313, 1891. Fig. F
Specimens examined: Z. L. Yang 622, 702 (HKAS 22115, 22116 respectively), on rotten bamboo stumps.
Distr.: Tropical Asia (Vietnam, southern Yunnan of China) to tropical Africa (Kenya).
Note: This species appears in large numbers on dead stumps of bamboo in Xishuangbanna during the rainy season. It is similar to F. pustulosa (Jungh.) Singer, a species reported previously from southern China, but the latter are of smaller spores (Teng, 1963).

7. Lepiota ianthinosquamosa Pegler in Kew Bull. Add. Ser IX: 389, fig. 75j-m; Pl.12C,1983. Fig. G
Specimen examined: Z. L. Yang 717 (HKAS 22129), on soil.
Distr.: Only known from Martinique of the Lesser Antilles and from southern Yunnan of China.
Note: The above collection, of dark-coloured squamules on the pileus and the stipe, large spores with strong suprahilar depressions, and clavate to subcylindrical cheilocystidia,is close to the species Lepiota ianthinosquamosa

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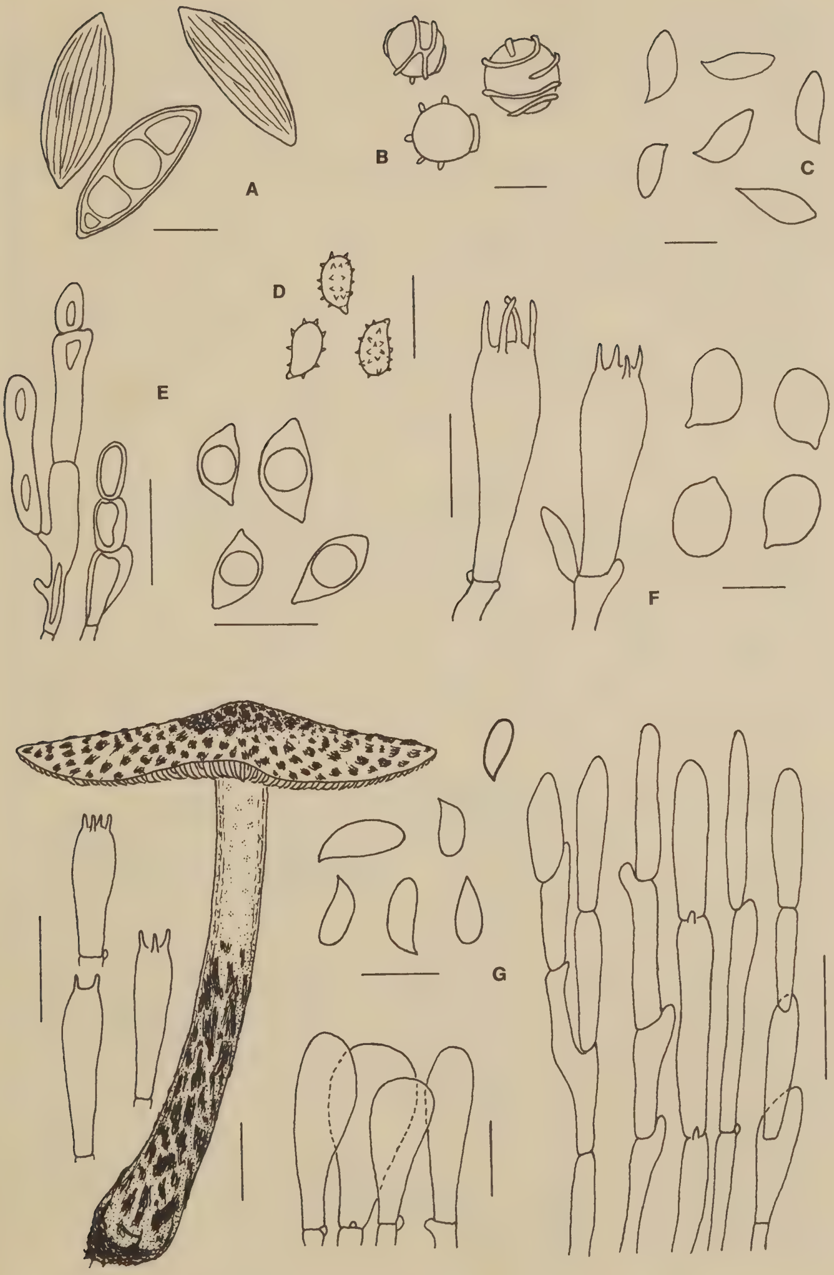
Figs. A-G: A. Cookeina indica Pfister et Kaushal: spores; B. Lamprospora lobata (Berk. et Curt.) Seaver: spores; C. Pterulicium xylogenum (Berk. et Br.) Corner: spores; D. Ramaria capucina (Pat.) Petersen: spores; E. Cyptotrama asprata (Berk.) Redhead et Ginns: spores, and pileipellis; F. Favolaschia tonkinensis (Pat.) Singer: spores, and basidia; G. Lepiota ianthinosquamosa Pegler: basidiocarp, basidia, spores, cheilocystidia, and pileipellis. Scales for basidiocarps 1 cm, for spores 10 µm, for cheilocystidia 10 µm, for basidia 20 µm, for pileipellis 40 µm.


A
B
C
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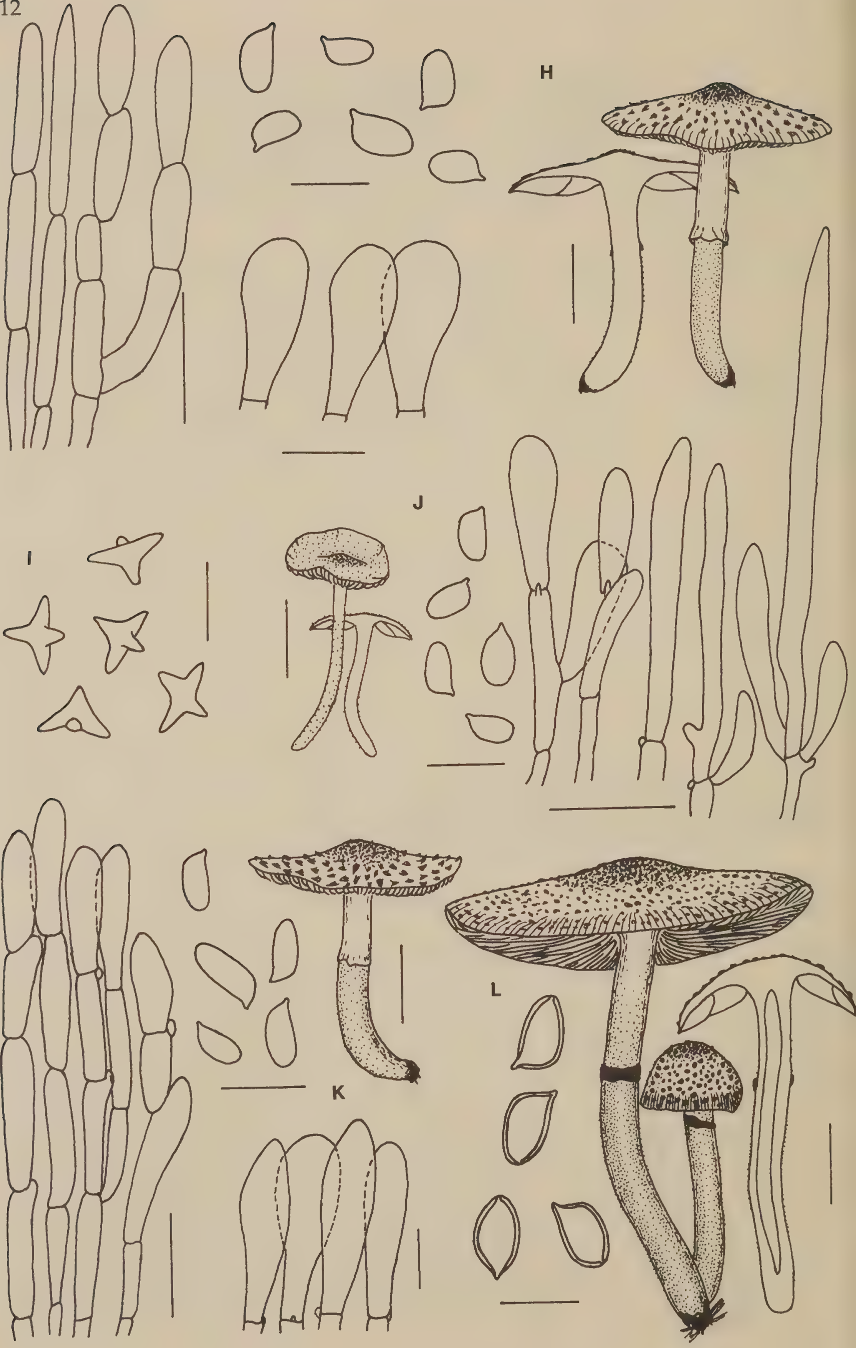
H
I
J
K
L

Pegler. The author does not intend to propose it a new name, although the stipe of our collection is longer (7 cm), and its context at the base is pink.

8. Lepiota phaeosticta Morgan in J. Mycol. 12: 248, 1906. Fig. H
Specimens examined: Z. L. Yang 569, 856, 827, 855 (HKAS 21803, 22126, 22127, 22128 respectively), on soil in tropical forests.
Distr.: Pantropical.
Note: The above collections agree well with the concept of this species (Pegler, 1977) except that the squamules on the pileus are somewhat reflexed.

9. Pterospora nigripes (Schw.) Horak in Sydowia 36: 133, 1983. ——— Agaricus nigripes Schw. in Schr. Nat. Ges. Leipz. 1: 84, 1822. Fig. I
Specimens examined: Z. L. Yang 320, 848 (HKAS 21894, 22491 respectively), on rotten leaves.
Distr.: Pantropical.
Note: The above two collections agree with the concept of this species (Pegler, 1977, 1983; Horak, 1983).

10. Lepiota subincarnata J. Lange, Fl. Agar. Danica I: 34, t. 13/1, 1935, nom. nud.; et Fl. Agar. Danica 5, Taxonomic Conspectus: V, 1940, descr. Fig. J
Specimen examined: Z. L. Yang 566 (HKAS 21804),

Figs. H-L: H. Lepiota phaeosticta Morgan: basidiocarp, spores, cheilocystidia, and pileipellis; I. Pterospora nigripes (Schw.) Horak: spores; J. Lepiota subincarnata J. Lange: basidiocarp, spores, and pileipellis; K. Lepiota phlyctaenodes (Berk. et Br.) Sacc.: basidiocarp, spores, cheilocystidia, and pileipellis ; L. Leucocoprinus bresadolae (Schulz.) Moser: basidiocarp, ans spores. Scales same to Figs. A-G.

on rotten leaves under a bush.
Distr.: Europe, Africa and Asia (southern Yunnan of China).
Note: Occurring usually amongst conifers, this species has also been found under a tropic bush in southern Yunnan. Our specimen agrees with the description of this species (Pegler, 1977).

11. *Lepiota phlyctaenodes* (Berk. et Br.) Sacc., Syll. Fung. 5: 52,1887. ——— *Agaricus phlyctaenodes* Berk. et Br. in J. Linn. Soc., Bot. 11: 501, 1871. Fig. K
Specimen examined: Z. L. Yang 726 (HKAS 22125), on soil in a plantation of oil palm (*Elaeis guineensis* Jacq.).
Distr.: Tropical Africa (Tanzania) to tropical Asia (Sri Lanka, India, and southern Yunnan of China).
Note: This species looks like *Lepiota phaeosticta* Morgan, yet the latter has shorter and wider spores, and its hyphae do not bear clamp-connexions.

12. *Leucocoprinus bresadolae* (Schulz.) Moser in Gams, Kleine Krypt. Bd. II b/2 Ed. 3: 186,1967. ——— *Lepiota bresadolae* Schulz.in Hedwigia 24: 132, 1885. Fig. L
Specimen examined: Z. L. Yang 351 (HKAS 21800), on rotten woods in tropical forests.
Distr.: Europe to Asia (Japan, southern Yunnan of China).
Note: Our specimen agrees with collections of Japan (Imazeki and Hongo, 1970) except that the context of the above specimen is white,unchanging, which may imply some variations among different populations.

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SARCOSCYPHA IN NORTH AMERICA (PEZIZALES, SARCOSCYPHACEAE)

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ABSTRACT

The genus *Sarcoscypha* (Fr.) Boudier (Discomycetes, Pezizales) is redefined for North America. Taxonomic studies of the *Sarcoscypha coccinea* complex reveal that there are three morphologically distinct species previously confused in North America as *S. coccinea*. Data on ascocarp morphology, the anamorphic state (*Molliardiomyces*), cultural characteristics, and distribution patterns support recognition of four species in North America (*S. austriaca*, *S. dudleyi*, *S. coccinea*, and *S. occidentalis*). *Molliardiomyces dudleyi* and *M. eucoccinea* are described as new species. Keys to North American species of *Sarcoscypha*, corrected synonymies, and descriptions of the genus and species are provided.

KEYWORDS: *Sarcoscypha, Molliardiomyces, Plectania, Peziza,* Sarcoscyphaceae, Sarcosomataceae, Operculate Discomycetes, suboperculum.

TABLE OF CONTENTS

Introduction 417
Material and methods 418
Morphology and anatomy 421
Cultural studies and the anamoph: *Molliardiomyces* Paden . . . 427
Delimitation of taxa and their distribution 435
History and nomenclature 437
Generic description 439
Key to North American species of *Sarcoscypha* 440
Accepted species 440
Excluded and doubtful taxa 451
Acknowledgements 454
Literature cited 455

Introduction

Well-known to amateur mycologists as "scarlet-cups," the species of the predominantly temperate genus *Sarcoscypha* (Fries) Boudier are widely distributed and frequently collected yet rarely correctly identified. In some fungi meaningful patterns of variation are difficult to detect due to the few gross structural characters available for analysis. *Sarcoscypha* contains a species complex which has been mistaken for a single variable species. As a result, the taxonomy of *Sarcoscypha* was unresolved for many years.

Until recently (Baral, 1984a, b) it was assumed that there were just two North American species of *Sarcoscypha*. The species with the larger cups was regularly identified as *S. coccinea* (Jacq. : Fr.) Lambotte (but using a variety of incorrect author citations) and the smaller-cupped species as *S. occidentalis* (Schw.) Sacc. It is within the larger-cupped species that taxonomy has been problematic. Most authors did not detect significant differences among those specimens identified as *Sarcoscypha coccinea* (Seaver, 1928; Gelin, 1938; Kanouse, 1948; Denison, 1972; Pfister, 1979a) while others noted differences worthy of varietal rank in spore shape (Boudier, 1903; Le Gal, 1941). When Pfister (1979a) examined the type material of *Peziza dudleyi* Peck, he concurred with Kanouse (1948) that it was "morphologically identical to *S. coccinea*." A few researchers (Alexopoulos and Butler, 1949; Rosinski, 1953; Paden, 1972) noted different types of spore germination among specimens identified as *S. coccinea*. Paden (1984) expressed concern when he described the anamorph of *S. coccinea*. He noticed that there existed considerable differences in the conidium size and growth rate among cultures from different collections, yet all cultures came from teleomorphs identified as *S. coccinea*. When Baral (1984b) provided a new combination for one North American species in his treatment of the European taxa within the *S. coccinea* complex [*S. dudleyi* (Peck) Baral], he failed to recognize that the type collection consisted of two elements, *S. dudleyi* and *S. austriaca* (Beck ex Sacc.) Boud.

This paper presents a taxonomic study of *Sarcoscypha* in North America. Within the *Sarcoscypha coccinea* complex I recognize three species formerly identified as *S. coccinea* (Table 1) on the basis of ascospore germination, ascospore morphology, anamorph morphology, ectal excipulum structure, and type of hairs which cover the receptacle. Also included in this paper is the undisputed *S. occidentalis*. To facilitate recognition of North American *Sarcoscypha* species, a key is provided. All species are described with an annotated synonomy and illustrations. What is known of their life histories and ecological preferences in North America is presented.

Materials and methods

The species in these investigations were studied from fresh collections, from dried herbarium specimens, and from live cultures. Herbarium material (i.e., part of a dry apothecium) was treated with several drops of 95% ethanol, then rehydrated in distilled water for 2-5 min, depending on the condition and the size of the sample. Samples were placed in a 2% aqueous KOH solution for 2-3 min and subsequently placed in distilled water for 2-3

Table 1. Examples of misidentification in the North American literature, reported as *Sarcoscypha coccinea*.

Author:	re-determined as:
Hone 1909	*S. austriaca*
Seaver 1928	*S. dudleyi*
Alexopoulous & Butler 1949	*S. austriaca*
Rosinski 1953 (var. *jurana*)	*S. dudleyi*
Rosinski 1953	*S. austriaca*
Pfister 1979a	*S. dudleyi*
Paden 1984 (pro parte)	*S. austriaca*
Paden 1984 (pro parte)	*S. coccinea*

min. Part of a fresh or fully rehydrated apothecium was placed on the stage of a freezing microtome (Leitz-Wetzlar), embedded in a drop of 20% aqueous mucilage, and sectioned at 10-25 µm from the base of the apothecium towards the hymenium. Observations were made by placing several drops of lactophenol-cotton blue (Stevens, 1974) or lactophenol directly on the sectioned material. Studies of apothecia were also made using squash mounts and free-hand sections. Measurements were made from sections in distilled water, lactophenol, and lactophenol-cotton blue. Mounts were sealed with nail varnish.

Ascospores from live specimens and from herbarium material were measured. To ensure maturity of the spores from herbarium material a drop of distilled water was placed on the dried cup and rolled over the hymenial surface to collect the spores. The drop was collected with a syringe and ejected onto a slide. Fresh ascospores were obtained by attaching pieces (5mm × 5mm) of apothecia to the inner surface of a Petri dish cover with petroleum jelly. Ascospores were discharged onto slides placed in the Petri dish or directly onto the bottom of the Petri dish. Spores were also obtained by placing sterile cover glasses directly on apothecia. After a period of discharge, the cover glass was removed. The cover slip was then either aseptically transferred to an agar block on a slide and subsequently incubated in a sterile moist chamber, or examined directly in one of the aforementioned mountants. Spore measurements were determined by measuring 20-50 ascospores from each ascocarp.

The gross morphology reported for each species is based on observations of available specimens and on the original description. Type specimens were re-examined. The terms used to describe the microanatomy of the fungi follow Korf (1952, 1973).

Cultural studies were performed with isolates from American and Canadian samples. Cultures were obtained by attaching pieces of apothecia to the inner surface of a Petri dish cover to obtain fresh spores, but instead of allowing the discharged spores to fall onto slides or cover glasses, they were discharged onto 2% water agar or other media. The Petri dish cover was rotated (every 20 to 60 min.) to obtain sectors of discharged spores. Discs of agar, 1cm in diameter, were then removed aseptically from these sectors and used to prepare cultures.

Plates with 5mm or less depth of media were used to prepare slide cultures and germinate ascospores. Ascospore germination and development was observed on the thin plates under 400x or 1000x magnification. Mycelia cut from the margin of actively growing cultures was also used to initiate study cultures.

Spore germination was attempted on Difco Potato Dextrose Agar (PDA), Difco Corn Meal Agar (CMA), 2% aqueous Difco Agar (WA), and Difco Yeast Malt Agar (YMA). Vegetative and reproductive growth were studied on the same media. PDA and YMA contained a mixture of 10 mg streptomycin sulphate and 20 units penicillin/ml to reduce bacterial contamination. The petri dishes were incubated (Westinghouse model Fu017RRW6, Fisher Scientific #82, Forma Scientific #12) at 20-23 C in darkness or with alternating 12-h fluorescent light-dark cycles. Illumination was provided by Sylvania fluorescent tube lamps with 3.3 × 103-4.1 × 103 lux (300-375 ft. c) light. Tests for temperature maxima were made with approximately 300 isolates. All tests were performed at least twice with five or six replicates at each temperature. Descriptions of the cultures were made at 4 to 5 weeks. Apothecia never developed in culture. Plates were inoculated and allowed to grow at room conditions for several months. Colony diameters were measured every 7 days. Measurements of cultural microscopic characters were taken from material mounted in distilled water and in lactophenol-cotton blue. The optimum and maximum temperatures for growth of *Sarcoscypha* isolates were determined using a Poly-temp Thermostat. Temperature ranges from 10-30 C with 5 C increments, were used. Color names are from Ridgway (1912) and from Methuen's *Handbook of Colour* (Kornerup and Wanscher, 1983). Photomicrographs were taken from fresh material and herbarium material in lactophenol-cotton blue mounts using a Leitz microscope equipped with an Orthomat camera.

Asci were also observed with a scanning electron microscope. A small (5mm × 5 mm) sample of hymenium was excised from a mature apothecium of a rehydrated (1 hr) herbarium specimen or from fresh material. The rehydrated samples were fixed in 2% glutaraldehyde in 0.1 M cacodylate buffer for 2 hr at 4C. Fresh material was fixed in FAA for 12-36 hr. After several rinses in buffer, the samples were dehydrated through a graded ethanol series (10%, 25%, 40%, 60%, 75%, 85%, 95%, 100%) and then dried to a critical point (DCP-1 Critical Point Drying Apparatus). The material was then placed on a stub and coated with gold-palladium (Hummel V Sputter Coater). Examinations were made with an Amray 1200B scanning electron microscope (Meyer & Plaskowitz, 1989).

Drawings were made with a calibrated ocular micrometer in an Olympus (model EH) standard binocular microscope equipped with a Wild drawing tube. The structures that were drawn were mounted either in Soluble Blue

706-lactic acid or fresh water.

Abbreviations of literature citations are based on Botanico-Periodicum-Huntianum (Lawrence, et al., 1968).

Collections of herbarium material were obtained on loan from the following herbaria. The abbreviations for institutional herbaria are taken from Holmgren et al. (1981).

B.H., personal collection of H.O. Baral. Blaihofstr. 42, D-7400, Tübingen 9 (Pfrondorf), West Germany.

BPI, National Fungus Collections, Agricultural Research Center-West, Beltsville, Maryland 20705, U.S.A.

CUP, Department of Plant Pathology, Cornell University, Ithaca, New York 14853, U.S.A.

F.A.H., personal collection of the author, Bailey Hortorium, 510 Mann, Cornell University, Ithaca, New York 14853, U.S.A.

NYS, New York State Museum Herbarium, New York State Department of Education, Albany, New York 12224, U.S.A.

OSC, Herbarium, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331, U.S.A.

PC, Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris, France.

PH, Dept. of Botany, Academy of Natural Sciences, 19th and the Parkway, Philadelphia, Pennsylvania 19103,USA.

SFSU, San Francisco State University Herbarium, Department of Biology, San Francisco State University, 1600 Holloway, San Francisco, California 94132, U.S.A

TUB, Institut für Biologie I, Lehrbereich spezielle Botanik, Auf der Morgenstelle 1, D-7400 Tübingen, DDR.

UVIC, Department of Biology, University of Victoria, Victoria, B.C., Canada.

Morphology and anatomy

The ascocarp of all *Sarcoscypha* species can be sessile, subsessile or stipitate. The mature cup size range is 5 mm to 7 (-9, e.g., *S. dudleyi*) cm in diameter. The ascocarp shapes are diverse. Some species are predominantly cupulate while other species have apothecia which are peltate, reniform, bilabiate, elliptical, deltoid, obovate, or orbicular. In all species apothecia are at first subglobose and almost closed before the fruiting body expands to its mature shape. Hymenial development can be categorized as eugymnohymenial (van Brummelen, 1972). Hymenial color varies from orange (Ridgway, pl. II-9; Kornerup and Wanscher, pl. 7A8), to scarlet (Ridgway, pl. I-3; Kornerup and Wanscher, pl. 9A8), to purple-red (Ridgway, pl. I-1; Kornerup and Wanscher, pl. 11A8), and rarely white (Fig. 4a). As the cups mature, and depending on the quantity of microbes present, the color may fade. Carotenoid pigments (plectaniaxanthin and beta carotene) are housed within granules in the paraphyses (Arpin, 1968). The presence of the carotenoid pigment plectaniaxanthine is considered an evolutionarily advanced character (Arpin and Jensen, 1967). The albino forms (i.e., white cups) do not possess the red-colored granules in their paraphyses. Baral (1984a) compared three species (*S.coccinea, S. jurana,* and *S. austriaca*) using thin-layer paper chromatography but found no perceptible chemical differences in the pigments among these. The hymenium is concave with the paraphyses extending slightly beyond the apices of the asci. The receptacle surface is rugose to reticulate and rarely smooth. Depending on the species and type of hairs present, the receptacle is glabrous to glabrescent or pubescent to hoary.

The asci are thick-walled (1-2 µm), iodine negative, long-cylindrical, 8-spored, with opercula terminal or slightly eccentric. The asci are hyaline, aporhynque, i.e., not arising from croziers (Berthet, 1964), suboperculate, distinctly attenuate below into a hypha-like base, and centifugally mature seriatim (Denison, 1967). Eckblad (1968) reported the existence of distinct external ascal cross-lines in water mounts at 40x. These cross-lines were also detected by van Brummelen (1975) and electronmicrographs in this study show these horizontal lines as horizontally roughened areas (Fig. 1).

There has been much controversy over the existence of a suboperculum. According to Le Gal (1946) the presence of this structure established the Sarcoscyphaceae as a higher ranking taxon which she regarded as an intermediate between the rest of the operculates and the inoperculates. Le Gal (1946) described three types of apical apparatus within the Sarcoscyphaceae and classified *Sarcoscypha* with those elliptically-spored genera that had apically oriented opercula, an apical chamber, and a thick, subapical pad in the shape of an incomplete ring. Although many have accepted its existence (Nannfeldt, 1949; Korf, 1957; Rifai, 1968), others (Eckblad, 1968, 1972; van Brummelen, 1975, 1978; Samuelson, 1975; Samuelson & Kimbrough, 1978; Samuelson et al., 1980) have not been able to detect this ring-like feature. Some authors (Samuelson, 1975; Samuelson et al., 1980) believed that Le Gal's observations were artifacts of fixations or stains.

This study uses the term suboperculum as it was originally intended by Le Gal (1946) to describe the "open-ring" structure she observed. Le Gal believed the presence of this structure provided evidence for a common ancestry shared by the Pezizineae and the inoperculate genera. Others believed it never existed as originally described, thus refuting the basis for a close phylogenetic relationship of the Sarcoscyphineae with the Inoperculati (Eckblad, 1972; van Brummelen, 1975).

During the course of this study fresh material placed in a water mountant revealed an "open ring," the ends of which did not touch but rather came into close contact as depicted by Le Gal (1946). It was most easily observed in mature fresh material at the ascus apex as a small, colorless, mucilaginous mass (Le Gal, 1969). In addition, electronmicrographs of *S. dudleyi* and *S. occidentalis* support Le Gal's (1946) concept of a "charni–

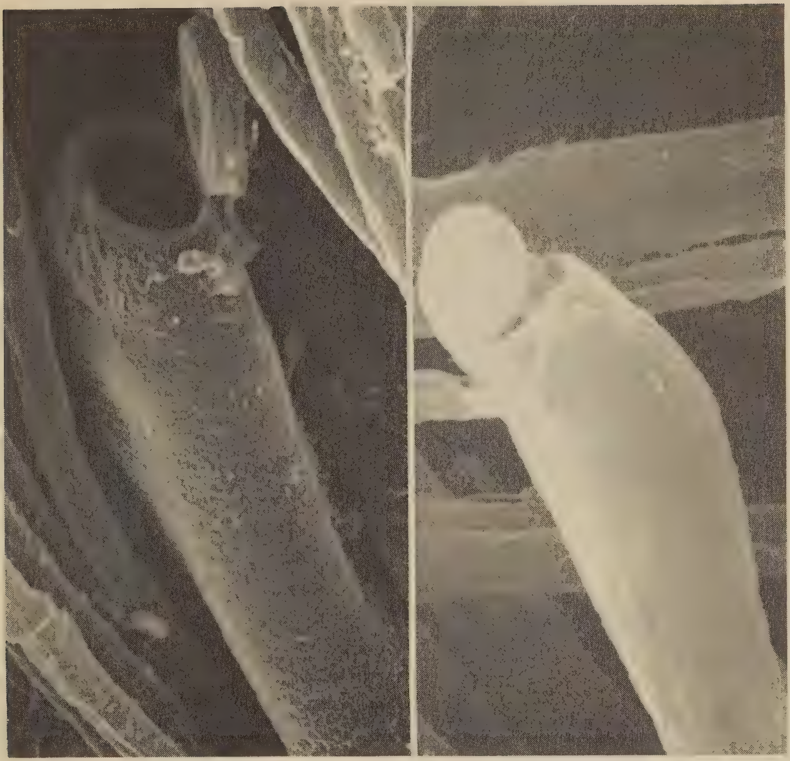

Fig. 1. Electronmicrograph of open ascus tip of *S. dudleyi* showing operculum and ascostome (two views, 5000x, CUP 62449).

ère" (i.e., the hinge-like attachment of the operculum to the ascostome, Fig. 2).

As she predicted the opercular hinge is formed on the ventral side (e.g., *S. dudleyi,* Fig. 1). Le Gal (1946) also described a condition where the "charnière" is much thinner. In this situation the operculum eventually falls off (e.g., *S. occidentalis*, Fig. 3).

The recent consensus (Samuelson, 1975; van Brummelen, 1978; Samuelson & Kimbrough, 1978; Samuelson et al., 1980; Donadini et al., 1989) based on electronmicrographs of apical apparatuses, is to use the term "suboperculum" to describe the area surrounding and beneath any operculum. Recent studies (Samuelson et al., 1980) indicate that the suboperculum occurs throughout the Pezizineae. Furthermore, it should not be considered a feature that sharply delimits the Sarcoscyphineae from the rest of the Pezizales.

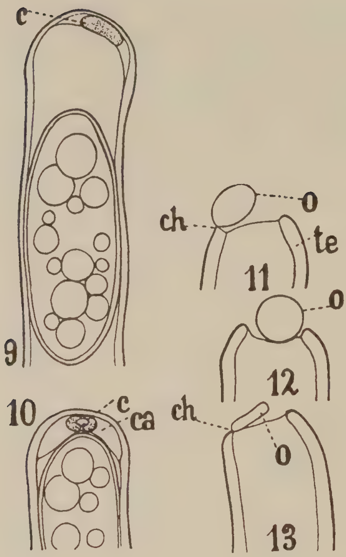

Fig. 2. The suboperculate ascus: ch= charnière, o= operculum (from fig. 6, Le Gal, 1946).

The ascospores in some species vary widely in size and shape within the same apothecium (sometimes within the same ascus). The mature ascospore wall is relatively thick (1-2 µm). In most of the Pezizales, during development of a single ascus all the ascospores are formed simultaneously through delimitation by an outer and inner delimiting unit membrane (Merkus, 1976). But in the *Sarcoscypha coccinea* it has been shown that the ascospores located in the basal parts of the ascus develop faster than those in the apical portion (Merkus, 1976). The ascospores of the Sarcoscyphaceae are plurinucleate at maturity, unlike most operculate discomycetes (Berthet, 1964). During development the ascospore has a primary wall which develops into an epispore and an endospore. Both the epispore and endospore are composed of inner and outer layers. The ascospore also develops a secondary wall (outside the primary wall) at the time that the primary wall is differentiating (Merkus, 1976). The spore shape can be ellipsoidal to truncate with bipolar depressions. The ascospores of *S. coccinea* and *S. dudleyi* are consistently ellipsoidal whereas *S. austriaca* displays shape and size variations within one apothecium. All species have a mucilaginous sheath surrounding each spore. This sheath is most probably the secondary wall of the ascospore as indicated by Merkus (1976). Although the spores of *S. dudleyi* are surrounded with this sheath when ejected from the ascus (Fig. 4b), the ascospores of *S. austriaca* have a cap-like remnant of the sheath found at the polar ends. Examinations of thousands of discharged spores of all the North American species onto cover slips or Petri dishes indicated that the eight spores within an ascus usually remain adherent and are ejected together.

The oil droplets (guttulae) found in the living ascospores of all species of *Sarcoscypha* are derived from globular structures (from endoplasmic reticulum) formed in the ascus during an early stage of ascal development (Merkus, 1976). These oil droplets are an important taxonomic feature for many of the operculates but may be of lesser importance in the inoperculates (Eckblad, 1968). Boudier (1907) noted the spores become eventually finely

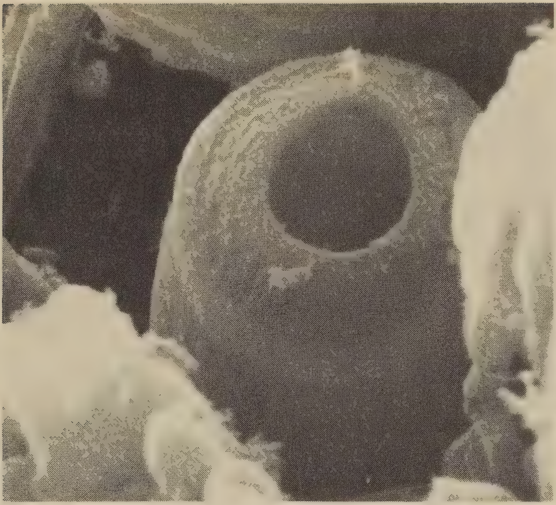

Fig. 3. Electronmicrograph of *S. occidentalis* ascal tip (5000x, CUP 62452)

granulose. I find the granular material to be restricted to a central region, forming a band separating the polar oil droplets. I follow Baral's (1984a, b) use of oil droplets in the ascospores as a significant taxonomic character in *Sarcoscypha.*

The paraphyses are septate, branch close to the base and approximately half way to the apex, anastomose, contain carotenoid pigments within granules, and have plurinucleate cells (Berthet, 1964). The apices may be rounded, clavate to a degree, and extend slightly (2-6 μm) beyond the asci. Gelatinous material embedding the paraphyses is absent. Among the *Sarcoscypha* species paraphyses are similar and hymenial hairs are lacking.

A thin, compact zone of tissue lies beneath the asci, giving rise to the asci and paraphyses. It is not a distinct subhymenial layer but rather an area of compressed textura intricata. The medullary excipulum consists of interwoven, hyaline hyphae (textura intricata) not in a gelatinous matrix, and may be extensive or relatively compact. The ectal excipulum consists of hyphae compressed into rectangular, hyaline to yellowish cells with few intercellular spaces (textura porrecta). The outer cells usually give rise to a tomentum of hyaline hyphae often enmeshing soil detritus. The ascocarp is used by insects (Diptera larvae, Collembola), isopods, and snails (Gastropoda) as a food source.

Chadefaud (1946), Berthet (1964), and Baral (1984a, b) have reported that the spores of *S. coccinea* are plurinucleate. Aragno (1966) demonstra–

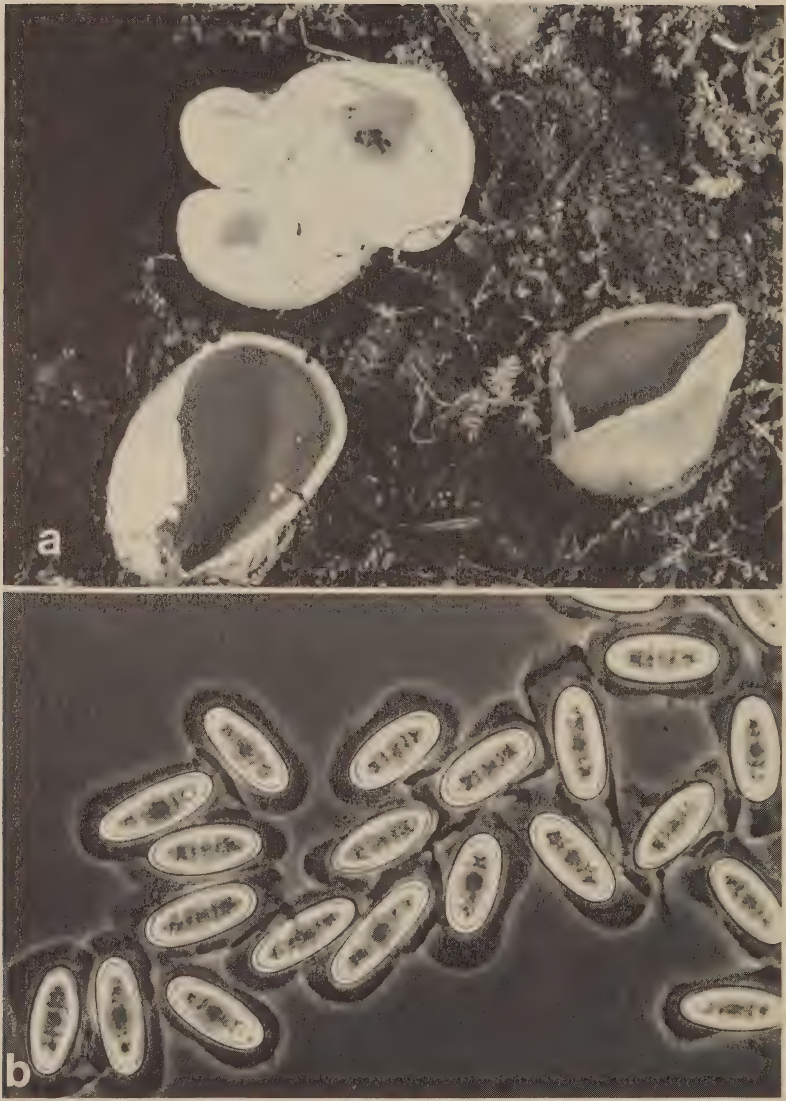

Fig. 4. *S. dudleyi*. a) white cup (CUP 62448); b) newly ejected spores with mucilaginous sheath (1500x, CUP 62446).

ted with *Sarcoscypha coccinea* that after the spore wall is delimited there are five synchronous divisions which result in 32 nuclei within each spore.

Cultural studies and the anamorph: *Molliardiomyces* Paden

In contrast to the taxonomic studies using apothecial characters in the Sarcoscyphaceae, little work has been done to delimit species on the basis of cultural characteristics or on the basis of anamorphs produced. Early works within the family included Boedijn's (1929, 1933) descriptions of the conidia borne on the ascospores of *Cookeina sulcipes* and *C. tricholoma*. The species of *Sarcoscypha* other than *S. coccinea* have only recently been studied in culture (Paden, 1983, 1984). Baral's revision (1984b) of the European species of *Sarcoscypha* included information on the germination of ascospores but there was little mention of the anamorphs. An additional purpose of my cultural studies was to explore the possibility of producing apothecia in vitro.

The ascospores of *S. dudleyi*, *S. austriaca*, *S. occidentalis,* and *S. coccinea* germinate readily on many media (WA, PDA, YMA). Ascospores of all species were found to germinate on water agar at 15-18 C in 1-4 days. Two types of germination have been observed and are similar to those found in the closely related genus *Phillipsia* Berkeley. In the first pattern of germination (Fig. 5, a-d, h) a single germ tube, which is usually polar, is produced. A second germ tube may erupt from the same site, the opposite pole, or may be produced laterally. Two germ tubes may erupt simultaneously from each pole. The germ tube grows quickly (at 15-20 C) and branches dichotomously after 3-4 hyphal segments are produced. Within the germinating ascospore the wall layers are easily detectable. As the germ tube grows the endospore separates from the epispore layer. The endospore diminishes in size as the germ tube elongates. This pattern is found in *Sarcoscypha dudleyi*, *S. coccinea* and *S. occidentalis*. It is similar to the germination pattern found in *Phillipsia lutea* Denison (Paden, 1974).

The ascospore germination of *S. austriaca* and occasionally of *S. occidentalis* represents the second type of germination (Fig. 5, e-g). Spore germination is a useful character to delimit *S. austriaca*. In this second type of germination, the ascospore may produce up to four polar germ tubes simultaneously. The germ tube(s) will swell and blastically produce conidia that are smooth, hyaline, ellipsoidal to obovate, with a truncate base. After and during conidial production hyphae will elongate from the polar ends. Although some authors (Rosinski, 1953; Paden, 1974; Baral, 1984a) have noted that some of the spores become one-septate during germination, others (Schäfer, 1986; this study) have not yet reported this phenomenon. It is not unusual for *S. austriaca* to have bipolar germination without the formation of conidia. Both conditions have been observed many times within the same Petri dish. Frequently the ascospores in this species will develop conidia while still in the ascus. This condition predominates as the apothecium

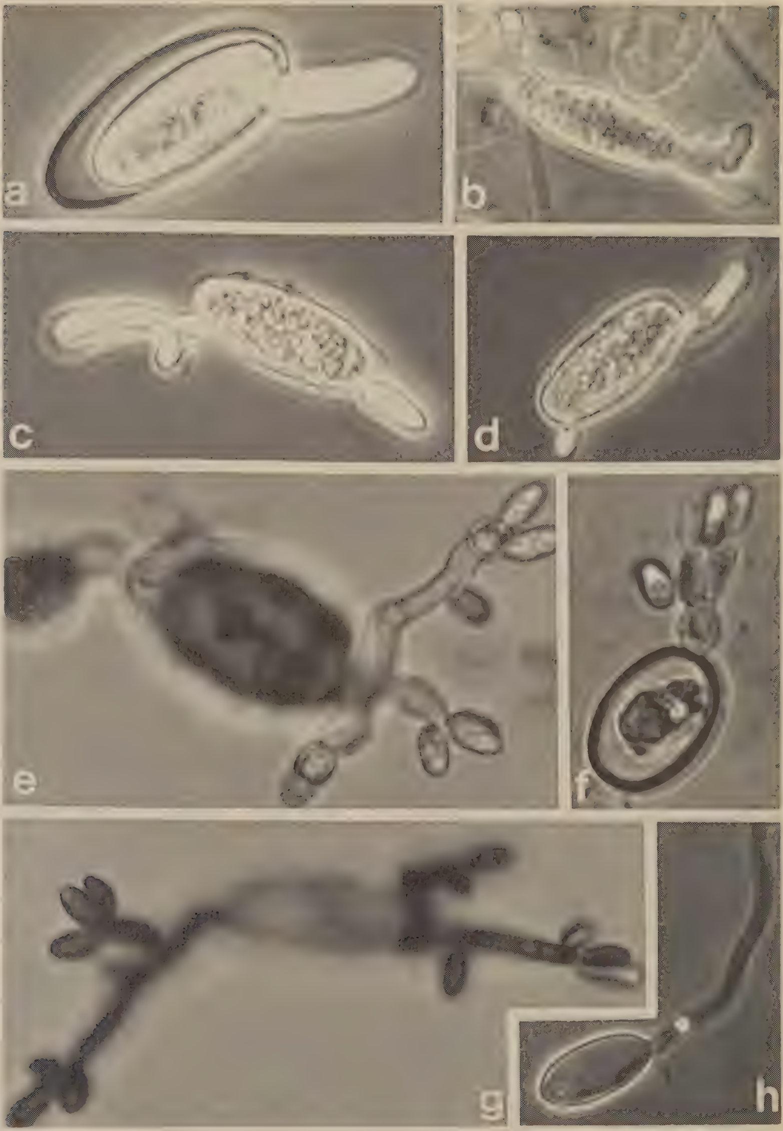

Fig 5. Types of ascospore germination: a-d *S.coccinea*. (a 1085x, b-d 1000x, CUP 62113); e) *S. austriaca*. (2800x, CUP 62451); f) *S. occidentalis* (3000x, CUP 62453); g) *S. austriaca* (2400x, CUP 62451); h) *S. dudleyi* (1200x, CUP 62446).

reaches maturity and starts to decompose. The age of an apothecium and humidity appear to be correlated to the number of ascospores germinating within the ascus. The condition of ascospores with conidia present within the ascus has occasionally been observed in *S. occidentalis* when the apothecium has started to deteriorate. The conidia in this species are usually produced from a single polar end but occasionally from both ends.

Although Molliard (1904) was the first to publish a description and illustration of the imperfect state for *Sarcoscypha,* he did not give a name to this form. Forty-five years elapsed before Alexopolous and Butler (1949) published their descriptions of ascospores with conidia borne on short conidiophores from collections of *S. austriaca* (reported as *S. coccinea).* Rosinski (1953) noted that spores of *Sarcoscypha* could germinate in either of two ways. Because only one of the collections he examined produced conidia, he speculated that the "two types of spore germination may lend support to Boudier's conclusion that there are 2 taxons involved." Recently, Paden (1984) established the genus *Molliardiomyces* for anamorphs with teleomorphs in the Sarcoscyphaceae (*Phillipsia* and *Sarcoscypha*). The conidia are smooth, one-celled, hyaline or yellowish, produced blastically from sympodially proliferating conidiogenous cells, are subglobose to obovate and often accumulate in mucilaginous masses. Paden found that the teleomorph of *S. coccinea* produced differences which he could not explain. The type species of *Molliardiomyces, M. coccinea* Paden, was assumed to be derived from *S. coccinea* (but my examination of the teleomorph collection used to produce the cultures revealed this species to be *S. austriaca*). *Molliardiomyces* has been found attached to ascospores of *S. austriaca* and *S. occidentalis* in nature and has been produced in culture for all the North American species. Conidia develop in two to three weeks at 18-20 C after a plate has been inoculated with hyphae. Germinating ascospores of *S. coccinea, S. dudleyi,* and *S. occidentalis* will produce hyphal conidia after 3 to 4 weeks at 18-20 C. Germinating ascospores of *S. austriaca* (without conidia present) may produce conidia on the germ tube within 48 hours at 18-20 C.

Two of the North American species (*S. austriaca* and *S. occidentalis*) have short conidiophores borne directly on the ascospore. This is usually the case when the apothecium is mature and begins to senesce. There is generally a single polar conidiophore produced in *S. occidentalis* whereas in *S. austriaca* the conidiophores erupt from either or both ends. It is common for conidia to develop within an ascus in *S. austriaca* and occasionally in *S. occidentalis.*

Though the term "conidium" is used throughout this paper for the anamorphic spore stage, it is possibly a misnomer. None of the conidia for any of the species (separated or attached) were observed to germinate, though extensive germination studies were undertaken involving tens of thousands of conidia. Since germination has not been observed (Rosinski

1953; Paden, 1972, 1974), it is not known whether these "conidia" function as either asexual spores or as spermatia, or indeed play any role in the biology of the species.

Cultural characters were obtained for each species by transferring germinated ascospores producing hyphae to agar plates (WA, PDA, and YMA). Cultures may be maintained on a variety of media. Colonies are usually white at first and may become orange grey (Kornerup and Wanscher, pl. 5B2) to yellowish white (Kornerup and Wanscher, pl. 4A2) with age. *Sarcoscypha dudleyi* and *S. occidentalis* may become shrimp pink to strawberry pink (Ridgway, pl. I), or peach (Kornerup and Wanscher, pl. 7A4) and may develop a ring of claret brown (Ridgway, pl. I) to black, irregularly shaped cells reminiscent of sclerotial rind anatomy (e.g., textura epidermoidea). Cultures were able to survive for 45 months without transfer to new media.

Interspecific (Fig. 6) and intraspecific pairings were performed with cultural isolates of all four species (WA, PDA, and YMA). The morphologies of the contact zones of interspecific pairings were varied and more distinct than those of intraspecific pairings. Three weeks after inoculation a depressed zone which may be interpreted as an area of "mutual aversion" was evident in all interspecific pairings. The contact zones were visible as a zone 3-7 mm wide. The hyphae on either side of the contact zone consisted of dense, compacted and low-lying hyphal growth apparently induced by the interaction.

The optimal temperatures for vegetative growth of *Sarcoscypha* species were 25 C for *S. occidentalis*, and 18-20 C for *S. dudleyi*, *S. austriaca* and *S. coccinea*. The species studied were able to grow slowly at temperatures above 6 C and below 37 C. Spores were not able to germinate above 33 C. There were no detectable differences between colonies grown in light/dark cycles, constant light, or constant darkness.

1. ***Molliardiomyces coccinea*** Paden, *Canad. J. Bot.* **62:** 212. 1984.

Teleomorphosis: *Sarcoscypha austriaca* (Beck ex Sacc.) Boud., *Hist. classific. discomyc. Europe*, p. 55. 1907.

Description: Paden (1984). Colonies fast growing on PDA at 18-20 C. Mycelium distinctively white, floccose to felty to cottony, never developing flattened areas or areas of textura epidermoidea, reverse an opaque white, no colors other than white. Conidiophores arising from the surface mycelium. Conidia large, 8.5-15 × 3.5- 5 µm, contents granular.

Holotype: Teleomorph collected in Quebec, Pinks Lake, Gatineau Hills Park, Canada, on buried *Quercus* twigs, 10 May 1970, leg S. Godkin, Paden 766, UVIC. Type is dried culture of Paden 766 in the University of Victoria Herbarium (UVIC).

Type locality: Canada, Quebec, Pinks Lake, Gatineau Hills Park.

Other specimens examined: NORWAY: Hordaland, Kuam, Mundheim, about 500 m S of the centre, in deciduous forest, 25 March 1973,

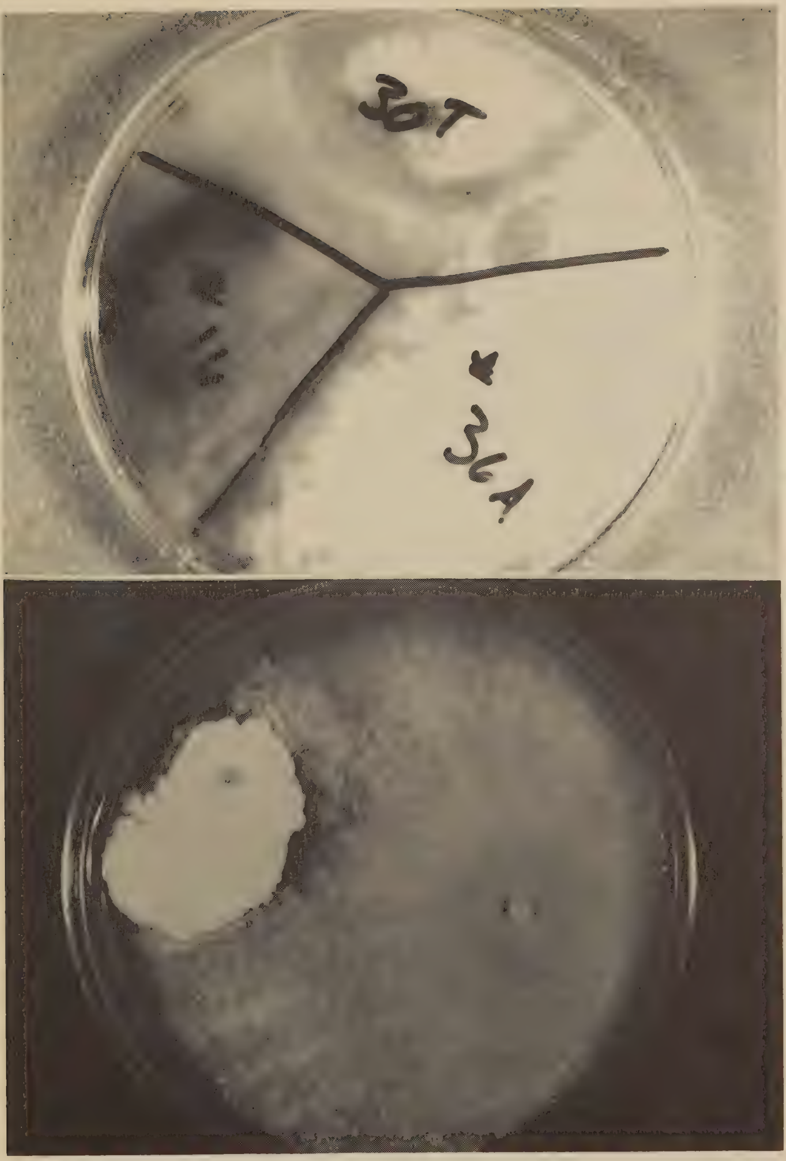

Fig. 6. Interspecific pairing on PDA agar plates of 4 species: a) *S. dudleyi* (CUP 62445, "30T"), *S. occidentalis* (CUP 62454, "16") and *S. austriaca* (CUP 62451, "36A"); b) *S. coccinea*, the small colony on left (Paden 571, UVIC) and *S. austriaca* (CUP 62451).

leg. J.V. Berge, (culture Paden 969) UVIC; UNITED STATES: **Maryland,** Frederick Co., Catoctin Mtn. Pk., 30 April 1986, leg. L.R. & S.T. Batra, CUP 62450; **New York**, Tompkins Co., 10 May 1984, leg. R. Dirig, CUP 60613.

2. *Molliardiomyces dudleyi* Harrington, sp. nov. (Fig. 7b)

Teleomorphosis: *Sarcoscypha dudleyi* (Peck) Baral, *Z. Mykol.* **50:** 124. 1984.

Conidiophora non vel asymmetrice dichotomeve deinceps ramosa, subhyalina vel pallide persicina, laevia, aliquando plus quam 150 µm longitudine × 2-4 µm latitudine. Regiones conidiogenae terminales, cicatricibus parum visibilibus. In PDA vel YMA annuli texturae epidermoideae concentrici complanati brunnei enati (18-23 C), myceliis superficialibus laxe intertextis superpositis. Cellulae conidiogenae sympodialiter multiplicatae, conidia singulariter producentes, cicatricibus locis ubi conidia discesserunt praeditae. Conidia blastica, ellipsoidalia vel obovata, subglobosa, laevia, hyalina, contento granulari instructa, basi parva truncata locum adhaesionis pristinae indicante praedita, 3.5-5.2 × 2.5-3 µm, in massis mucilaginis aliquando colore Eosine-rosaceo cumulata.

Description: Conidiophores unbranched to asymmetrically or dichotomously branched at several ranks, subhyaline to pale peach, smooth, sometimes exceeding 150 µm in length × 2-4 µm wide. Conidiogenous regions terminal with slightly visible scars. On PDA or YMA concentric flattened, brown rings of textura epidermoidea develop (18-23 C) with loosely-woven, overlying surface mycelia. Conidiogenous cells proliferating sympodially, producing conidia singly, bearing scars where conidia secede. Conidia blastic, ellipsoidal to obovate, subglobose, smooth, hyaline, contents granular, with a small truncate base indicating former points of attachment to conidiogenous cell, 3.5-5.2 × 2.5-3 µm, accumulating in mucilaginous masses which are sometimes Eosine pink colored (Ridgway, pl. I.-1). Cultures moderately fast growing on PDA (better than on YMA), 35-50 mm in diameter at 18-20 C in nine days. Cultural differences depended on whether a colony arose from a single ascospore or from multiple ascospores.

Colony growth from an agar plug of hyphae would first develop a felty flat area, then expand in height (ca. 6 mm) as the colony advanced in age and diameter. In general, colonies were white to light peach (Kornerup and Wanscher, 5A2, 5B3) and many developed a sweet, musty odor. Conidiophores formed mostly in region of epidermoidal cells. Some colonies produce conidial masses orange-white to peach (Kornerup and Wanscher, 7A4). Mycelia cottony to floccose, tan, dark-brown, with flattened concentric rings of epidermoidal cells, odor similar to teleomorph (i.e., with a scent not unlike *Rosa* sp.). Reverse cream to brown.

Holotype: Teleomorph collected in Delmont, Westmoreland Co., Pennsylvania, 5 February 1986, leg. E. Johnson, CUP 62445, culture deposited in

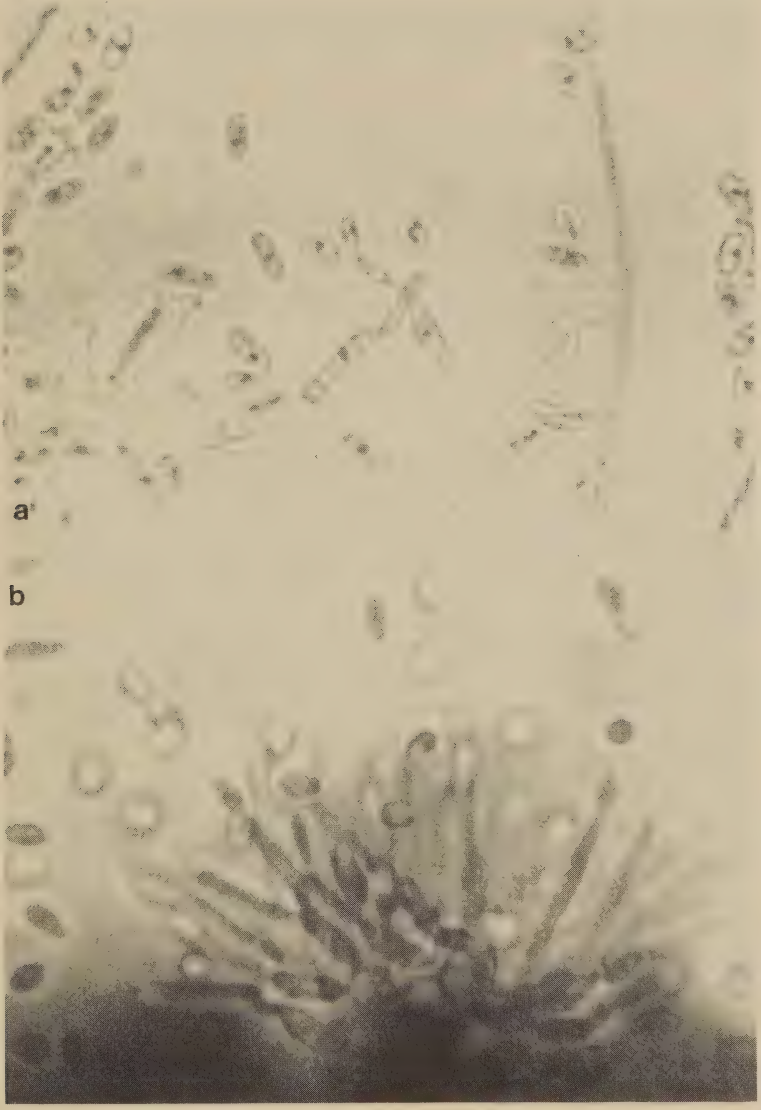

Fig. 7. Conidia and conidiophores of *Molliardiomyces* spp. a) *M. eucoccinea* Harrington (3000x, CUP 62113); b) *M. dudleyi* Harrington (3000x, CUP 62445).

ATCC, Rockville, MD.

Type locality: Delmont, Westmoreland Co., Pennsylvania.

Other specimens examined: **Pennsylvania**: Westmoreland Co., Delmont, 19 December 1985, leg. E. Johnson, CUP 62446; **New York:** Six Mile Creek, Tompkins Co., 8 January 1989, leg. F.A. Harrington, F.A.H. 120.

3. ***Molliardiomyces eucoccinea*** Harrington, sp. nov.(Fig. 7a)

Teleomorphosis: *Sarcoscypha coccinea* (Jacq.: Fr.) Lambotte, *Fl. mycol. belge, suppl.* **1:** 302. 1887.

Conidiophora plerumque prostrata, non vel asymmetrice ramosa, subhyalina, laevia, saepe plus quam 200 μm longitudine × 1.5-2 μm latitudine. Regiones conidiogenae cicatrices vix visibiles gerentes, cellulis sympodialiter multiplicatis. Conidia blastica, ellipsoidalia, tamen regione centri parum constricta, obovata, non-septata, hyalina vel pallide flava, contento granulari instructa, basi parva complanata locum adhaesionis pristinae indicante praedita, 4.4-6.5 × 2.2-3 μm, in massis mucilaginis cumulata.

Description: Conidiophores mostly prostate, unbranched or asymmetrically branched, subhyaline, smooth, often exceeding 200 μm in length × 1.5-2 μm wide. Conidiogenous regions bearing scarcely visible scars, cells, proliferating sympodially. Conidia blastic, ellipsoidal with the central region slightly constricted, obovate, non-septate, hyaline to pale yellow (Kornerup and Wanscher, 2A2), granular with a small flattened base indicating former points of attachment, 4.4-6.5 × 2.2-3 μm, accumulating in mucilaginous masses.

Colonies on PDA restricted to moderately fast growing, 25-40 mm in diameter in 14 days at 18 C, thin surface mycelium, predominantly white, reverse pale yellow to cream, felty to appressed to floccose. Conidiophores formed on tufted areas.

Holotype: Teleomorph collected in California: "coast live oak forest and mixed with digger pines, about 1/4 mile from ocean, ele. about 800 ft, ± 10 mi. N of Santa Cr.," Santa Cruz Co., 10 January 1989, leg. T.L. Harrington, CUP 62113; culture deposited in ATCC, Rockville, MD.

Type locality: California: Santa Cruz Co., near Scott Creek.

Other specimens examined: CANADA: Goldstream Provincial Park, British Columbia (culture of Paden 571), UVIC; UNITED STATES: **California**: Samuel P. Taylor Park, Marin Co., 25 February 1976, leg. J.W. Paden (Paden 1111), UVIC.

4. ***Molliardiomyces occidentalis*** Paden, *Canad. J. Bot.* **62:** 213. 1984.

Teleomorphosis: *Sarcoscypha occidentalis* (Schw.) Sacc., *Syll. fung.* **8:** 154. 1889.

Description: Paden (1984). Colonies on YMA (better growth and faster than on PDA) covering 9 cm diam Petri plate in 14 days at 15-20 C, with mycelium felty to cottony, loosely interwoven, white to cream, sometimes with appressed concentric areas that are greyish-orange to reddish-brown (Kornerup and Wanscher, 5B3 to 8E6). Reverse tan to reddish-brown. Conidiophores formed throughout the darkened concentric areas. Conidia 4.5-7 × 3.8 µm, contents granular.

Holotype: Teleomorph collected in Indiana: Hoosier National Forest, Teril Ridge, Brown Co., 31 May 1972, leg. M.B. Tansey, (culture of Paden 861) UVIC.

Type locality: United States, Hoosier National Forest, Indiana.

Other specimens examined: **Indiana**: Hoosier National Forest, Brown Co., 30 July 1972, leg. M.B. Tansey, UVIC; **Pennsylvania**: Murrysville, Westmoreland Co., 29 July 1985, leg. E. Johnson, CUP 62454; **New York**: Six Mile Ck., Tompkins Co., 8 June 1989, leg. F.A. Harrington & D. Potter, BPI.

Delimitation of taxa and their distribution

Based on studies of apothecial morphology and cultural characters, four distinct North American taxa should be recognized at the species level. This conclusion is also supported by the morphology of the asexual states (*Molliardiomyces* Paden). It is easy to understand how *S. dudleyi*, *S. austriaca*, and *S. coccinea* were confused as one species in North America. The three relatively large species are phenotypically similar, and overlap in their phenology while *S. dudleyi* and *S. austriaca* overlap in their geographic distribution. Until Baral's (1984a, b) study, all of the large North American species were identified as *S. coccinea*. The type collection of *S. dudleyi* includes both *S. austriaca* and *S. dudleyi* and one portion here is designated as lectotype. During the early part of this study it was assumed that *S. coccinea* did not occur in North America. Later fresh collections from California were compared with fresh material of *S. coccinea* from Europe. The material from California proved to be *S. coccinea*. The known distribution of *S. coccinea* in North America is only west of the Rocky Mountains. *S. occidentalis* had always been identified clearly due to its diminutive size and its occurrence in summer months.

Further evidence to support four species have been found through studies of the anamorphic states. Paden (1984) noted the crucial differences in conidium size and growth rate among cultures from different collections. He did not realize that he actually had two anamorphic species which he lumped under the name of *Molliardiomyces coccinea* Paden. Unfortunately the teleomorph of the holotype of *M. coccinea* is not *S. coccinea* but *S. austriaca*. The paratypic specimens of *M. coccinea*, Paden 571 and Paden 1111, do have *S. coccinea* teleomorphs according to my studies.

The two species of *Molliardiomyces* which connect to the teleomorphs of *S. dudleyi* and *S. coccinea* are described earlier in this paper.

The importance of fresh material for species diagnosis, especially for noting ascospore guttulation, cannot be overstated. Although I had examined material (dried herbarium specimens) from western North America I was not prepared to recognize that group as a species distinct from the two, large eastern North American species until I saw fresh (living) material. I was also confused by the cultures of Paden 571 and Paden 1111. These cultures were obtained from teleomorphs found in British Columbia and California. The conidia from these cultures were smaller than the conidia from Paden's type culture (Paden 766) of *Molliardiomyces coccinea.*

Baral (1984a, b) experienced a similar situation with *S. dudleyi.* Although he had examined Peck's type material of *Peziza dudleyi* Peck, he was unable to recognize that the packet also included material of *S. austriaca.* Baral did not have the opportunity to examine fresh material of *S. dudleyi* from the United States.

Sarcoscypha is a widely distributed and relatively common genus, but restricted to localized populations. The species which Europe and North America share are *S. coccinea* and *S. austriaca*. Two North American species are not found in Europe (*S. occidentalis* and *S. dudleyi*) and two European species do not occur in North America (*S. jurana* and *S. macaronesica* Baral & Korf). It is difficult to draw valid conclusions about specific ranges, particularly with respect to those members within the *S. coccinea* complex. In North America the most widely distributed species is *S. occidentalis*. The range of *S. occidentalis* is throughout the continental United States east of the Rocky Mountains. It is probable that *S. occidentalis* also occurs throughout Central America and the Caribbean (Denison, 1972). *Sarcoscypha austriaca* is found in the north-central and eastern United States, and central to eastern Canada. *Sarcoscypha coccinea,* common in Europe, has the most restricted range in North America. It has been collected from California, Oregon, Washington and British Columbia. *Sarcoscypha dudleyi* occurs primarily in the central and eastern (most probably southeastern) United States and southeastern Canada. It overlaps temporally and regionally with *S. austriaca*.

All species of *Sarcoscypha* are restricted to the substrates of angiosperm (e.g., *Quercus* L., *Acer* L., and *Tilia* L.) twigs and branchlets that have started to decompose and are partially buried within the top 5 cm of soil and forest litter. The habitat is usually moist, shaded soil with a high humus content.

In the United States *S. occidentalis* can be collected in the late spring (May) and throughout the summer months and into September. *S. dudleyi*, *S. coccinea,* and *S. austriaca* are evident from the late autumn, but the ascospores normally do not reach maturity till late January, and mature apothecia can be collected to mid spring.

History and nomenclature

The history of the generic name *Sarcoscypha* begins with the Friesian (1822) "tribe" *Sarcoscyphae,* (a rank under *Peziza* series *Lachnea*) which delimited 29 species of small to large fleshy cups that were sessile to stipitate, with a wooly exiciple. The apothecial colors included red, yellow, green, brown, black, and blue. Berkeley (1860) was the first author to elevate *Sarcoscypha* to subgeneric rank, while others (Berkeley and Broome, 1866; Cooke and Peck, 1872; Phillips and Plowright, 1875; Cooke, 1871, 1874, 1875) used *Sarcoscypha* or *Sarcoscyphae* at an unspecified infrageneric rank. Under the subgenus *Sarcoscypha*, in the influential work *Mycographia,* Cooke (1875-1879) included species such as those included by Fries (1822), predominantly stipitate red, yellow, orange, tan, brown, or black cups. Boudier's (1885) natural classification based on the mode of ascus dehiscence recognized seven operculate discomycete families. He elevated *Sarcoscypha* from Fries's tribal rank to generic rank. *Sarcoscypha* (Fries) Boudier was restricted in his key to the red cups, and he listed two "espèces principales," *Peziza coccinea* and *P. occidentalis*. The many diverse other elements recognized by Fries and Cooke were placed elsewhere in Boudier's classification. To accommodate the black cups he raised *Peziza* subgenus *Rhizopodella* Cooke to generic rank. He designated *Peziza melastoma* as the type for this genus. Saccardo (1889) followed Boudier for *Sarcoscypha* but added orange and yellow cups, which expanded the number of species to twenty. Saccardo adopted Fuckel's (1870) generic name *Plectania* for the black cups, which had priority over *Rhizopodella* when so lectotypified by Saccardo.

Cooke's (1892) generic concept of *Sarcoscypha* in his *Handbook of Australian Fungi* was essentially still that of his earlier subgenus, and is broader than the concept of any other workers, previous or since. He included red cups, black cups and brown cups in the genus *Sarcoscypha*. The genus was divided into 3 infrageneric taxa. Within the first division (unnamed but titled "brightly colored") were the following species (using modern names): *Sarcoscypha coccinea*, *Geopyxis majalis* (Fr.) Sacc. (cfr. Rifai, 1968), *Cookeina colensoi* (Berk.) Seaver (cfr. Rifai, 1968), and *Sowerbyella rhenana* (Fuckel) Moravec (1986). The next division, *Macropodia,* contained only the species *Helvella macropus* (Pers. : Fr.) Karst. (cfr. Dissing, 1966). *Plectania,* the final infrageneric division, included only the black-cup species *Plectania melastoma* (Sow. : Fr.) Fuckel. Hone (1909) followed Cooke's (1875-1879) initial (pl. 27, 1875) treatment in subgenus *Sarcoscypha*, but not assignment to subgenus *Rhizopodella* in the 1879 Index Systematicus to that work when she placed the following red and black cup species in *Sarcoscypha: S. melastoma, S. coccinea, S. occidentalis* and *S. floccosa* (Schw.) Sacc.

Fifteen years before *Sarcoscypha* was raised to generic rank, Fuckel (1870) erected the genus *Plectania* for two markedly different cup-fungi, both original members of Fries's (1822) "tribe" *Sarcoscyphae*. *Plectania coccinea* was used for a scarlet cup and *Plectania melastoma* for a black cup. Fuckel did not designate a type for his generic name (Korf, 1953), but one of the two must serve as its type. Confusion arose when Seaver (1928) overturned Saccardo's (1889) treatment of *Sarcoscypha* and *Plectania* and applied *Plectania* to *Sarcoscypha coccinea* and other red cups. He placed the black cups in the genus *Bulgaria* Fries. According to Rifai (1968), Seaver followed the automatic first-species method when he chose *Peziza coccinea* as the lectotype of *Plectania*. Unfortunately, others (Gelin, 1938; Kanouse, 1948; Nannfeldt, 1949; Le Gal, 1953; Berthet, 1964) accepted this arrangement. Kanouse (1948) vigorously defended Seaver's decision to revive *Plectania* but transferred two of his species to other genera. Korf (1953) discussed the nomenclatural situation and restored *Sarcoscypha* (Fries) Boudier, and noted (Korf, 1972) that the species within *Sarcoscypha* needed to be further examined. Some authors (Hone, 1909; Denison, 1963) have placed species in *Sarcoscypha* which are now recognized in *Microstoma* Bernst., *Nanoscypha* Denison, and *Plectania* Fuckel. Baral's (1984a, b) significant revision of the European *Sarcoscypha* species represents the most recent close examination since Le Gal (1953). Within the European and Macaronesian *S. coccinea* complex Baral detected 4 distinct species, *S. austriaca*, *S. coccinea*, *S. jurana* and *S. macaronesica,* and provided a new combination for a North American species of the complex *(S. dudleyi)*.

The classification of this North American revision follows Rifai (1968) and Korf (1970, 1972) wherein the Operculate Discomycetes are separated into 2 suborders, the Pezizineae and the Sarcoscyphineae. Korf (1970, 1972) divided the Sarcoscyphineae into two distinct families, the Sarcosomataceae and the Sarcoscyphaceae. Some recent authors (Eriksson, 1984; Hawksworth et al., 1983; Eriksson and Hawksworth, 1986, 1988), however, recognize a single family and have merged these two families as the Sarcosomataceae. The Sarcoscyphaceae is characterized by brightly colored apothecia, usually with carotenoids in the hymenium, ascospores which are either smooth or with longitudinal ridges or reticulations that are cyanophobic (Denison, 1965), paraphysis cells that are multinucleate (Berthet, 1964), and the lack of hymenial hairs (Rifai, 1968). Members of the genus *Sarcoscypha* are distinguished from other family members primarily by their ascospores, asci, and excipular tissue (Denison, 1972).

GENERIC DESCRIPTION

Sarcoscypha (Fr. : Fr.) Boudier, *Bull. Soc. Mycol. France* **1**: 103. 1885.
≡ *Peziza* [Dill.] : Fr. 'trib.' *Sarcoscyphae* Fr., *Syst. mycol.* **2**(1): 78. 1822.
≡ [*Peziza* 'trib.' *Sarcoscyphi* Martius, *Fl. crypt. erlang.*, p. 469. 1817, *nomen invalid.*]
≡ *Peziza* subg. *Sarcoscypha* (Fr. : Fr.) Berk., *Outl. Brit. fungol.* p. 367. 1860.
≡ *Peziza* sect. *Sarcoscyphae* (Fr. : Fr.) Cooke, *Handb. Brit. fung.* **2**: 679. 1871.
= *Peziza* * [infrageneric rank not stated] *Scypharia* Quél., *Mém. Soc. Emul. Montbéliard* II **5**: 398. 1873.
≡ *Peziza* subg. *Scypharia* (Quél.) Quél., *Enchir. fung.*, p. 281. 1886.
≡ *Scypharia* (Quél.) Quél., *Compt.-Rend. Assoc. franç. Av. Sci.* (Grenoble 1885) **14** (2): 451. 1886 (later homonym of *Scypharia* Miers, 1860).
Typus conservandem propositus, T.: *Sarcoscypha coccinea* (Jacq.: Fr.) Lambotte (*Peziza coccinea* Jacq. : Fries) (Korf & Harrington, 1990).

Apothecium solitary to gregarious, deep cupulate when young, cupulate to flat at maturity, at times reniform, bilabiate, dimidiate or wedge-shaped, cupulate to deep cupulate when dry, centrally, laterally, to very eccentrically attached, sessile or stipitate; stipe twisted and with furrows when dry; apothecia 5 mm to 7 (-9) cm diameter, margin crenulate when young, laciniate at maturity, slightly incurved to strongly enrolled, recurved at maturity or when dry. **Hymenium** brightly colored, scarlet, China red, cinnabar, vermillion (Kornerup and Wanscher, pl. 9A8), vivid red (Kornerup and Wanscher, pl. 8B8), rose red (Ridgway, pl. XII-71), scarlet, scarlet red, spectrum red (Ridgway, pl. 1), rarely white when fresh; orange, deep chrome, cadmium yellow (Ridgway, pl. III), apricot orange to cinnamon rufous (Ridgway, pl. XIV) when dry, without hymenial hairs. Subhymenium indistinguishable from excipulum or of a slightly compacted zone of textura intricata. **Receptacle** ecru to white when fresh (also dilute shades of hymenial color not uncommon), tan to beige when dry; surface rugose, netted, sulcate, or pitted, flexuous hyphae on stipe and at its base, basal hyphae often enmeshing detritus; superficial hairs slightly flexuous to tightly coiled, hyaline to subhyaline, thin-walled, septate, 10-100 μm long with rounded apex, originating from cells in the ectal excipulum; ectal excipulum of textura porrecta, medullary excipulum of well-developed textura intricata, hyphae slender, septate. **Stipe** ectal excipulum of textura porrecta, hairs arising from the outermost cells, texture soft-leathery when young, brittle and twisted with furrows when dry. **Asci** 8-spored, thick-walled, long (240-500 × 14-18 μm), cylindrical, characteristically tapering into a hypha-like base embedded deep in the subhymenium, non-reactive in Melzer's reagent.

Ascospores smooth, size variable (18-40 × 9-15 µm) uniseriate, hyaline, ellipsoidal or oblong ellipsoidal to subcylindrical, in some species truncated with or without polar depressions, smooth-walled, containing many small (1-3 µm) or two large (4.5-6 µm) oil droplets, with a non-staining, ephemeral mucilaginous sheath (not detectable in old herbarium material). **Paraphyses** filiform, slender, divided and branching, filled with carotenoid granules, septate, slightly enlarged at apices, exceeding asci (2-6 µm). **Habitat** shaded to open areas moist enough to support moss populations, on twigs and branchlets at least two years old that are partially buried beneath leaves.

Key to the North American species of *Sarcoscypha*

1. Apothecia stipitate, small to medium-sized, 5-20 mm broad, glabrous or glabrescent, ascospores generally smaller than 21 × 12 µm, occasionally a single, polar conidiophore present on ascospore, occurring in late spring to summer . . . . *S. occidentalis*

1´. Apothecia stipitate to subsessile, medium sized to large, 15-90 mm broad, exterior tomentose, ascospores larger than 20 × 11-12 µm; occurring from late fall to mid-spring 2

2. Twisted, curvy hairs arise from within the ectal excipulum; ascospores mostly truncate with many small polar droplets (less than 3 µm diameter); conidiophores often present at either or both ends of ascospore . . . . *S. austriaca*

2´. Hairs relatively straight or slightly flexuous, arising from outermost cells of ectal excipulum, ascospores rarely truncate, predominantly ellipsoidal; conidiophores not produced on ascospores 3

3. Apothecia with hairs straight, not flexuous; ascospores multi-guttulate or spumose (guttules 1.5-3.5 µm diam), appearing frothy . . . . *S. coccinea*

3´. Apothecia with hairs slightly curved but neither strongly twisted nor straight; ascospores biguttulate (i.e., at each end there is a large guttule), polar guttules usually 5-6 µm diam with smaller (1.5-2 µm.) guttules present . . . . *S. dudleyi*

Accepted Species

1. ***Sarcoscypha austriaca*** (Beck ex Sacc.) Boud., *Hist. classific. discomyc. Europe,* p. 55. 1907. (Figs. 5e, g; 6a, b; 8)
≡ *Lachnea austriaca* Beck ex Sacc., *Syll. fung.* **8**: 169. 1889.
= ? *Peziza epidendra* Bulliard, *Herb. Fr.* pl. 467, fig. 3. 1789.

Anamorph: *Molliardiomyces coccinea* Paden.

Apothecium cup-shaped, discoid or reniform, ear-shaped, sessile, subsessile or stipitate, laterally attached or very eccentric, 1-6 (-7) cm in diameter when fresh, hymenium spectrum red (Ridgway, pl. I), dull red or other shades of red when dry, receptacle surface an opaque tint of hymenial color, buff colored when dry (Kornerup and Wanscher, 3A2, 4A2), brown pustules with isodiametric cells enmeshed with detritus, cartilaginous to rubbery when fresh, becoming leathery when dry. **Ectal excipulum** of textura porrecta, 35-100 µm thick, cells hyaline to subhyaline, axes of cells parallel to the outer surface, 8-11 µm wide × 10- 50 µm long, these cells generally larger than in any other North American *Sarcoscypha* species, the most inflated cells occurring closest to the medullary excipulum; hairs 4-5 µm wide, abundant, septate, hyaline, arising from within the ectal excipulum, extensively curved and intertwined. **Medullary excipulum** together with subhymenium

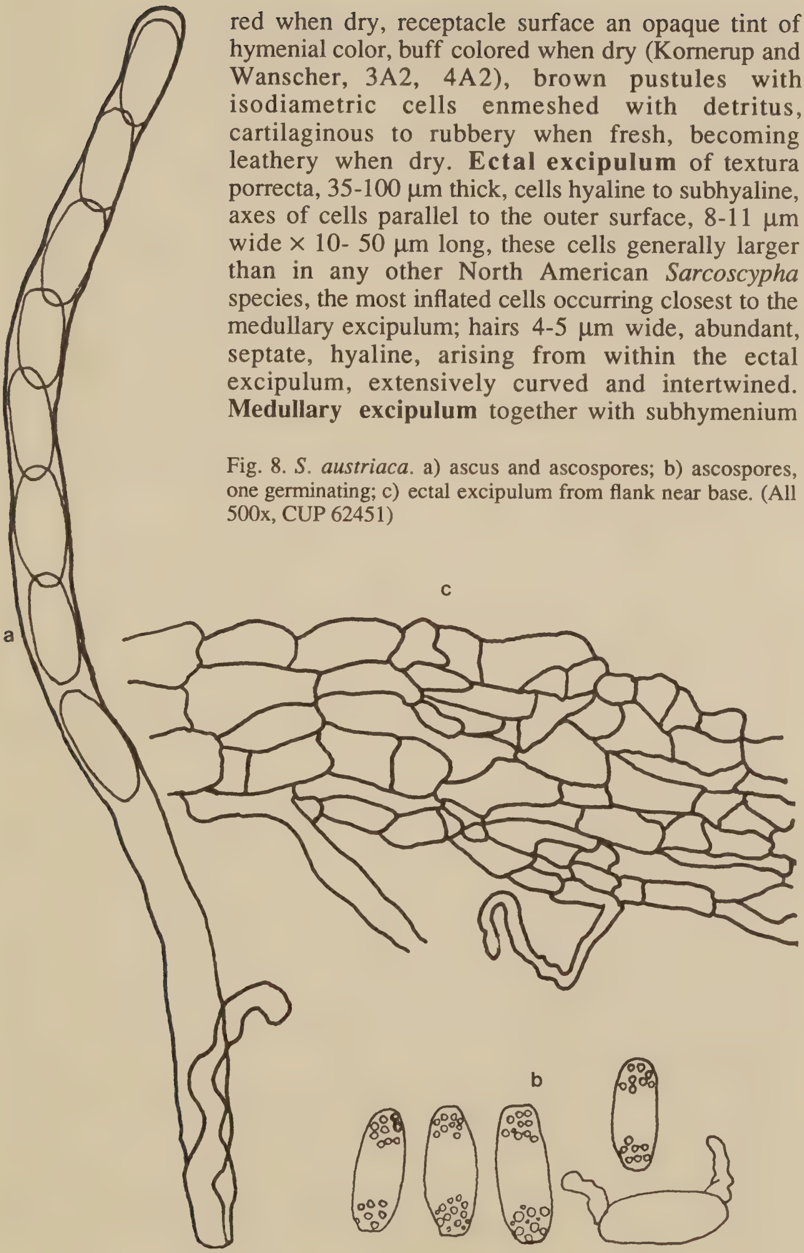

Fig. 8. *S. austriaca*. a) ascus and ascospores; b) ascospores, one germinating; c) ectal excipulum from flank near base. (All 500x, CUP 62451)

900-1300 µm thick, hyphae hyaline to subhyaline, more or less parallel to the outer surface. **Asci** long-cylindrical, gradually tapering at base, 375-485 × 18-19 µm. **Ascospores** enclosed in mucilaginous sheath which is later reduced to caps at the spore ends at time of ejection, ellipsoidal or truncate cylindrical shapes with pronounced polar depressions, many small (ca. 1.5-3 µm) polar droplets, presence of ascospore-borne conidia not uncommon in ascus of mature hymenium, ascospores 25-36 × 9.5-12 µm. **Paraphyses** 2-3 µm wide, slightly clavate at apex, long-cylindrical, filiform, branched, septate near base, anastomosing, extending 2-4.5 µm beyond ascus apices.

Neotype: According to Baral (1984a, b), holotype material not found. Neotype from: Baden-Württenberg, BR Deutschland, "unter der St. Wilhelmer Viehhütte, MTB 8113, 47°53'N, 7°59'E, Meereshöhe 1200-1250 m, *Aceri-Fagetum,* Gibirgsbach, auf schwach basischem Gneis, auf Ast von *Acer pseudoplatanus,* 20.5.79. leg. H.O. Baral, P.Laber, & D. Laber, H.B. 2537. Neotype specimen deposited in TUB.

Neotype locality: Bannwald Napf, Baden-Würtenberg, West Germany.

Habitat: On partially buried deciduous twigs (e.g., *Acer*) in moist habitats. Immature apothecia may appear in late fall; most cups are mature from mid to late spring.

Distribution in N.A.: South-central and southeastern Canada and north-central and north-eastern United States.

Other specimens examined: CANADA: ONTARIO, "wet soil under *Acer saccharum*, *Fraxinus nigra*," 15 May 1975, leg. S. Godkin, UVIC; "near Guelph, mixed hardwood forest," 1 May 1977, leg. S. Godkin, UVIC; London, "on decaying limbs partly buried in the ground, April 1893, leg. J. Dearness, BPI; Leeds Co., Big Rideau Lake, "on twig," 13 May 1984, leg. K.Brown & D. Stotz, UVIC; QUEBEC: Pinks Lake, Gatineau Hills Park, "*Quercus* buried twigs," 10 May 1970, leg. S. Godkin, UVIC; Papineau Co., Cantley, 13 May 1970, leg. A. Ginns, UVIC. **NORWAY:** Hordalend, Kvam, Mundheim, "about 500 m S of the centre in deciduous forest," 25 March 1973, leg. J.V. Berge, UVIC. **WEST GERMANY:** Schwarzwald, Feldberg Bannwald Napf, MTB 8113, ca. 1250m NN, Bergsteilwald mit *Picea*, *Fraxinus* und *Acer*, an Ästchen von *Acer pseudoplatanus,* 22 May 1977, leg. P. and D. Laber, det. H.O. Baral, H.B. 2051; 7742 Perach, 370 m Auwald, auf *Alnus* 11 April 1979, leg. Gruber, H.B. 2614; 8430 Hohenschwangau *Aceri-Fagetum*, auf *Acer,* April 1981, leg. A. Bollman, H.B. 2611. **UNITED STATES:** MARYLAND: Catoctin Mtn. Pk., Frederick Co., 30 April 1986, L.R. & S.T. Batra, CUP 62451; MINNESOTA: Hennepin Co., Phelps Is., 44°55´23´´N, 93°38´45´´W, "buried in the ground," 18 May 1905, leg. D.S. Hone, BPI; NEW YORK: Madison Co., "on decaying wood, hardwood-conifer forest, feeder canal to Chenango Canal, North of Hamilton," 22 May 1973, leg. K.H. & V.B. McKnight, BPI; Alcove, [Albany Co.], no date, leg. C.L. Shear, (as *Peziza concentrica* Seaver), BPI; Onondaga Co., Skaneateles, Clintonville Gorge, "on buried wood," 13 May 1976, leg. K.H. McKnight, BPI; Tompkins Co., Dryden, German Crossroad, New York, “on sticks on ground," 17-18 April 1952, leg. H. Lyon, CUP 38758; Tompkins Co., Ithaca, “Six Mile Creek gorge, ca. 3300 ft. SE Van Natta’s dam on buried branch of *Acer saccharum*," 10 May 1984, leg. R. Dirig, CUP 60613; VERMONT: Tinmouth, [Rutland Co.], “on buried wood west slope of the Purchase, 20 April 1923, C.W. Dodge & D.H. Linden; Mt Tabor, [Bennington Co.], “on *Acer saccharum*," Marshall, 7 May 1936, leg. H.G. Eno, BPI; WEST VIRGINIA: Morgantown, [Monongalia Co.], “on wood” “bright red on wood," 7 April 1907, leg. J.L. Sheldon, CUP-D 6458 (31-38). **USSR**: ESTONIA: Tartu, “substr. on rotten wood of *Corylus avellana*," 27 April 1958, leg. A. Raitviir, Nr. 329, BPI.

Etymology: According to Baral (1984a, b), the epithet *austriaca* refers to the fact that this species is widespread in Austria.

2. ***Sarcoscypha coccinea*** (Jacq. : Fr.) Lambotte, *Fl. mycol. belge*, suppl. 1: 302. 1887 (ut “Jacq.”). (Figs. 5a-d, 6b, 9)
  ≡ [*Elvela coccinea* Schaeff., *Fung. Bavar. Palat. Nasc.* **4:** 100. 1774 (later homonym of *E. coccinea* Scop. 1772).]
  ≡ *Peziza coccinea* Jacq., *Fl. austriac.* 2: pl. 163. 1774 (new name, Art. 72, note 1) : Fr., *Syst. mycol*. **2**: 79. 1822 [Jacquin, *Misc. austriac.* **1:** 40. 1778 clearly indicated that *P. coccinea* of 1774 was intended as a transfer of Schaeffer’s name, not as a new species].
  ≡ *Macroscyphus coccineus* (Jacq. : Fr.) Gray, *Nat. arr. Brit*. pl. **1:** 672. 1821 [by citing Persoon, who cites Jacq.].
  ≡ *Plectania coccinea* (Jacq. : Fr.) Fuckel, *Jahrb. Nassauischen Vereins Naturk.* **23-24:** 324. 1870.
  ≡ *Lachnea coccinea* (Jacq. : Fr.) Gillet, *Champ. France discomyc*. p. 66. 1880.
  ≡ *Sarcoscypha coccinea* (Jacq.) Cooke ex Molliard, *Bull. Soc. Mycol. France* **20:** 139. 1904 [later homonym].
  ≡ *Sarcoscypha coccinea* (Jacq.) Fr. ex Grelet?, *Bull. Soc. Bot. Centre-Ouest* **1938:** 75. 1938 [later homonym].
  ≡ *Sarcoscypha coccinea* ‘Fries ex Jacquin’ ex Chadefaud, *Compt.-Rend. Hebd. Séances Acad. Sci.* **222:** 753. 1946 [later homonym].
= *Elvela coccinea* Scop., *Fl. carniol.*, ed. 2, **2:** 479. 1772.
  ≡ *Geopyxis coccinea* (Scop.) Massee, *Brit. fung. fl*. **4:** 377. 1895.
  ≡ *Plectania coccinea* (Scop.) Fuckel ex Seaver, *N. Amer. Cup-Fungi* (*Oper*.), p. 191. 1928; [later homonym of *P. coccinea* (Jacq. : Fr.) Fuckel (1870)].
  ≡ *Sarcoscypha coccinea* (Scop.) Sacc. ex Durand, *Bull. Torrey Bot. Club* **27:** 477. 1900.
= [*Peziza coccinea* Bolt., *Hist. fung. Halifax* **3:** 104, pl. 104, 1790 (later homonym of *P. coccinea* Jacq. 1774).]

Anamorph: *Molliardiomyces eucoccinea* Harrington.

Apothecium discoid to cupulate or ear-shaped at maturity, deep cupulate or subglobose when young, tough-fleshy to rubbery when fresh, becoming leathery when dry, sessile, subsessile or occasionally stipitate, up to 4 cm broad. **Stipe** may be stout, tomentose or not, 1.5-4 mm thick, length depending on the substrate, of textura porrecta, centrally attached or eccentric, subiculum present beneath receptacle or not. **Hymenium** scarlet to red (Kornerup and Wanscher, 10A8) fading to orange (Kornerup and Wanscher, 7B8) when dry, receptacle with an opaque tint of the hymenium, at times hoary due to presence of tomentose hyphae, margin strongly incurved when immature, when dry puckered, furrowed with stipe slightly twisted. **Ectal excipulum** of textura porrecta, thickness depending on circumference of substrate, usually 45-80 µm, hyphae hyaline, cells 12-45 × 3-10 µm, cells parallel to the outer surface of the apothecium; hyaline hyphae (3-5 µm wide) extend only from the outermost cells, thin-walled, slightly flexuous and

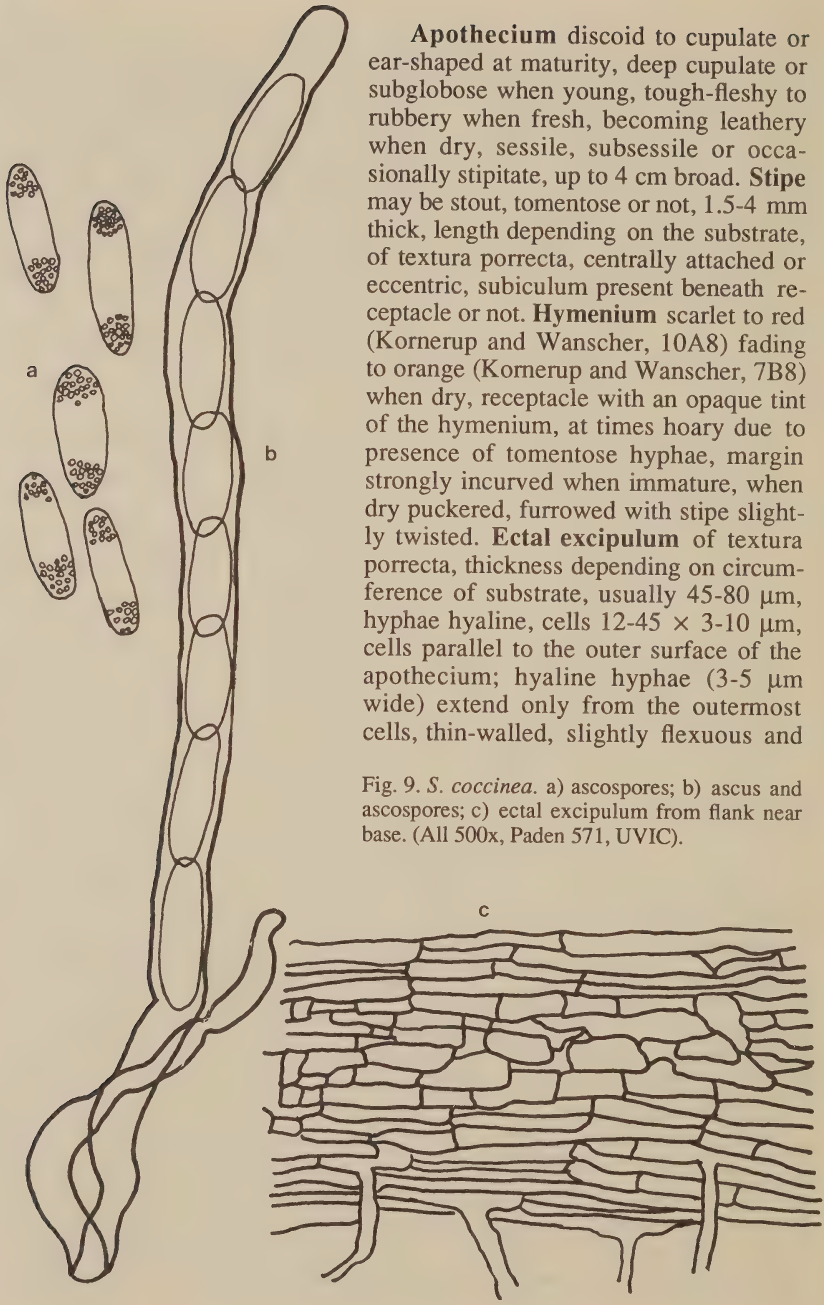

Fig. 9. *S. coccinea.* a) ascospores; b) ascus and ascospores; c) ectal excipulum from flank near base. (All 500x, Paden 571, UVIC).

occasionally enmeshing detritus. **Medullary excipulum** of textura intricata, 920-1,250 µm thick, hyphae subhyaline, loosely interwoven, scattered with large spaces (holes). **Asci** gradually tapering basally, reaching a length of 375-475 µm and a diameter of 13-15 µm, containing numerous small oil droplets when young, eguttulate at maturity. **Ascospores** oblong-ellipsoid or narrowly ellipsoid, not truncate, 25-35 × 11-14 µm, with a mucilaginous sheath, absence of large oil droplets (i.e., over 3 µm in diam), numerous small oil droplets aggregating towards polar ends, germinating from either or both ends simultaneously. **Paraphyses** cylindrical, slender, about 2.5 µm wide, septate in lower portion, branched, occasionally anastomosing.

Neotype: Baral (1984a, b) designated a neotype because the type no longer exists. Neotype from West Germany, Baden-Württemburg, Hambrücken, Schönborner Mühle, am Saalbach, MTB 6817, 49°11´N, 8°32´E, Meereshöhe 107m, 12.3.79., leg. K.H. Wamuth & H.O. Baral, H.B. 2460; deposited at Tübingen (TUB).

Neotype locality: West Germany, Baden-Württemburg, Hambrücken.

Habitat: Wet areas of mixed deciduous and coniferous forests on partially buried sticks, particularly *Quercus,* in the early to middle spring.

Distribution in N. A.: Canada: British Columbia, Vancouver Island. United States: California, Oregon and Washington.

Other specimens examined: CANADA: BRITISH COLUMBIA, Vancouver Island, Goldstream Park, 23 March 1968, leg. G. Cheesman. **FRANCE:** Reboutier, 87-38 Thouarce-Le Mesnil, auf *Ulmus*, 25 February 1979, H.B. 2570. **SWITZERLAND:** Chlenglweg 101, CH 8240, Thayugen, January 1988, leg. P. Blank, F.A.H. 119. **WEST GERMANY:** Baden-Württemburg, Hambrücken, Schönborner Mühle, MTB 6817, "*Aceri-Fraxinetum*? mit *Acer platanoides*, *Ulmus carpinifolia*, *Corydalis cava & solida*, *Gagea lutea*, *Arum*, *Ficaria*, *Lamium* sp., *Viola odorata*, *Glechoma*, ebener Auwald, Löß?, sandige humose Braunerde, auf *Ulmus carpinifolia*, 16 February to 5 March 1977, leg. Waßmuth, H.B. 2353. **UNITED STATES:** CALIFORNIA, Marin Co., Samuel P. Taylor State Park, 25 February 1976, leg. H.D. Thiers, SFSU; Marin Co., Near Inverness, "in woods on old wet sticks buried in leaves," March 1931, leg. W. B. Cooke, SFSU; Marin Co., Pt. Reyes National Seashore, "scattered on rotten wood," 10 January 1976, leg. R. Halling, SFSU; Marin Co., Limantour Ridge, "on hardwood, 17 October 1981, leg. L. Swiedon; Santa Cruz Co., "coast live oak forest and mixed with digger pines, about 1/4 mile from ocean, ele. about 800 ft, ± 10 miles N of Santa Cruz," January 1989, leg. T.L. Harrington, CUP 62113; San Mateo Co., San Francisco Watershed, "scattered on dead oak logs," 24 February 1970, leg. H. D. Thiers, SFSU; OREGON: Benton Co., Corvallis, Willamette Park,"on wood in branches and litter near Willamette river," no date, leg. D. Walter, OSU 45272; [Clatsop Co.], Astoria, February 1906, leg. Panamore, CUP-D 565 (31-7); [Lane Co.], Eugene,Tobury Rd, "woods," 10 March 1945, OSU 37974; Linn Co., Colorado Lake, 4 February 1933, leg. C. E. Owens, OSU 5684; Marion

Co., Silver Creek Falls, "on forest duff," no date, leg. Dr. Bellinger, OSU 13164; WASHINGTON: Snohomish Co., Pilchuck Ck., "common along creek," 15 January 1964, R.L. Vadas, BPI.

Etymology: The epithet *coccinea* comes from Latin, deep red, from scarlet to carmine (Stearn, 1987).

Nomenclatural notes: This species has regularly been cited with a variety of author citations. Names adopted by Fries in the *Systema Mycologicum* and in the *Elenchus Fungorum* are sanctioned (Art. 13.1, ICBN) and represent a special exception to the starting point for the nomenclature of "fungi caeteri" (Korf, 1983). In the index to vol. 3 of the *Systema*, Fries cites Jacquin as the author of *Peziza coccinea*. In *Misc. austriaca* Jacquin (1778) intended to transfer Schaeffer's *Elvela coccinea* to *Peziza* but *E. coccinea* Schaeffer (1774) is considered a later homonym of *E. coccinea* Scopoli (1772) (which has a different type than Jacquin's material, but is presumably conspecific). Jacquin's (1774) *Peziza coccinea* must be considered a new name (Art. 72, note 1). Fries listed *E. coccinea* Scopoli as a taxonomic synonym of *P. coccinea* Jacquin. Thus, the correct citation is *Peziza coccinea* Jacq. : Fr. and not *P. coccinea* Scop. : Fr. (Korf and Harrington, 1990).

3. ***Sarcoscypha dudleyi*** (Peck) Baral, *Z. Mykol.* **50:** 124. 1984, descr. emend. (Figs. 1, 4a, b, 5h, 6a, 10)
≡*Peziza dudleyi* Peck, *Annual Rep. New York State Mus.* **47:** 23. 1894.

Anamorph: *Molliardiomyces dudleyi* Harrington.

Because the ascocarps of the *Sarcoscypha coccinea* complex are macroscopically similar, the description of *Sarcoscypha dudleyi* is emended. The lectotype I have designated is labelled apothecium #7 in the type collection. **Apothecium** goblet or cup-shaped when young, fan-shaped, spoon-shaped, ear-shaped or reniform at maturity, sessile to subsessile, centrally attached or eccentric, at times slightly convex when dry, 1- 6.5 cm in diameter when dry (cup size depends upon size of host), subiculum not uncommon on substrate, margin strongly incurved and crenulate when young but recurved at maturity and becoming laciniate, hymenium grenadine red (Ridgway, pl. II), to scarlet (Ridgway, pl. I) or rarely white when fresh, xanthine orange to cadmium orange (Ridgway, pl. III) when dry. **Receptacle** opaque tint of the hymenial color, scattered light brown pustules, these cells brown, isodiametric, forming areas enmeshed with particles of detritus, sparsely or heavily tomentose, surface not smooth but finely puckered and horizontally furrowed. **Ectal excipulum** of textura porrecta, 40-65 µm thick, with occasional inflated cells (i.e. cells are generally rectangular), each cell 4-5 µm wide, axes of cells parallel to the outer surface, hairs hyaline, septate, 3.5-4 µm wide, slightly curved, not strongly twisted. **Medullary excipulum** of textura intricata 100-700 µm thick, hyphae hyaline to subhyaline, more or less parallel to the outer surface. **Asci** long cylindrical, gradually tapering basally, sometimes with a bulbous inflated area near apex, 260-400 × 13-18 µm, containing numerous small oil droplets when young. **Ascospores** more consistent in size than variable, 20-38 × 9 -15.5 µm, shape predominantly oblong-elliptical, no bipolar depressions, at each end, usually single large (5-7.5 µm) polar guttule, many smaller guttules (droplets) present, thick-walled, encased in mucilaginous sheath when discharged, 27-39 × 12-15 µm.

Holotype: New York, Tompkins Co., Coy Glen, October 1888, leg. W. R. Dudley, "on wood or bark." Lectotype designated here (apothecium number #7 of approximately 10 cups present). Included in this collection are also apothecia of *Sarcoscypha austriaca*. NYS, Albany, New York.

Type locality: New York, Tompkins Co., Coy Glen.

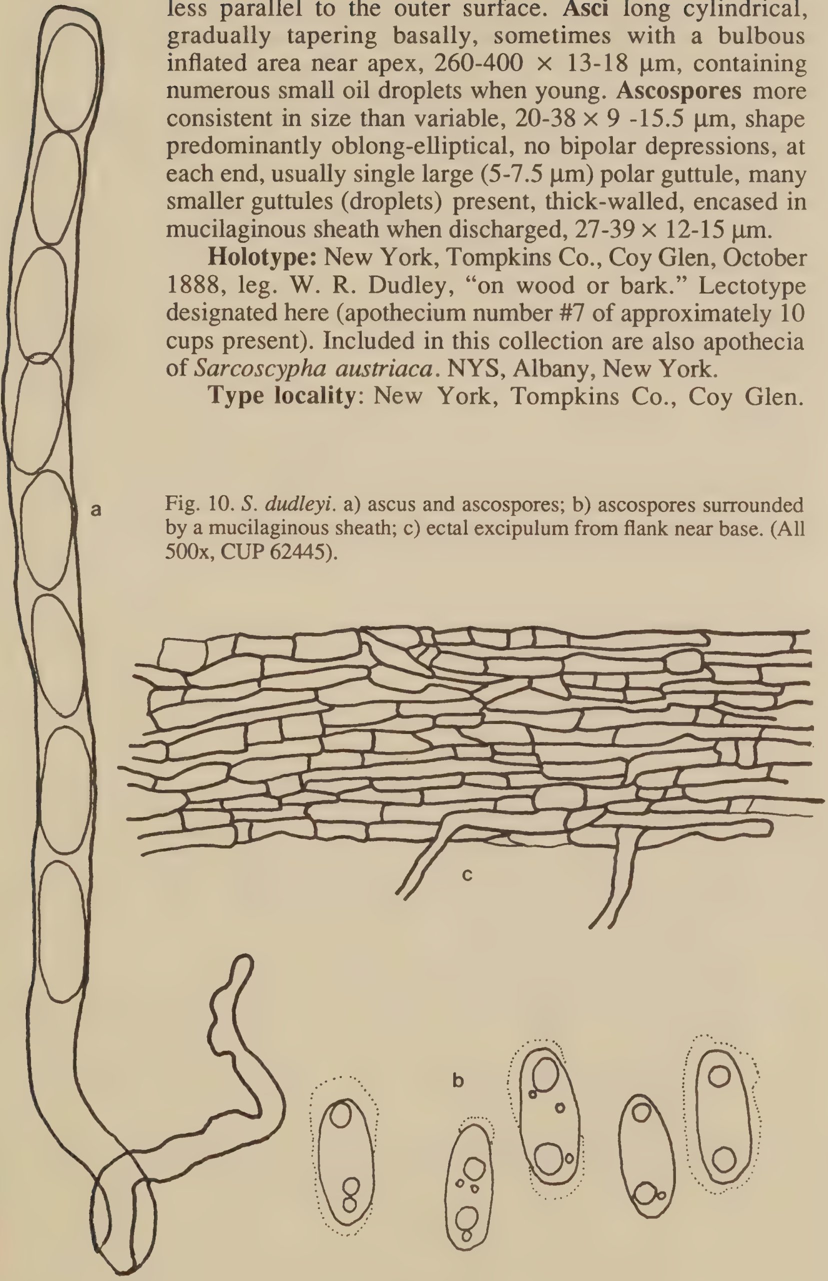

Fig. 10. *S. dudleyi*. a) ascus and ascospores; b) ascospores surrounded by a mucilaginous sheath; c) ectal excipulum from flank near base. (All 500x, CUP 62445).

Habitat: On partially buried twigs (e.g., *Tilia)* in deciduous forests that retain enough moisture to support mosses growing on or near substrate, rarely dry, generally covered with leaves. Immature cups appear in the late fall and most do not mature till the following spring.

Distribution: Central to eastern United States.

Other specimens examined: **United States**: IOWA: Mt. Pleasant, [Henry Co.], "on buried sticks," April 1906, leg. Seaver, BPI; MINNESOTA: Brown Co., New Ulm, May 1885, BPI; Fort Snelling Reservation, [Hennepin Co.], "dead sticks," "ex Herb. Wm Trelease," 12 April 1919, leg. E.J. Durand, CUP-D 10692 (31-49), Minneapolis, Minniehaha Glen, 12 April 1919, leg. E.J. Durand, CUP-D 10691 (31-48); MISSOURI: St. Louis, [St. Louis Co.], April 1886, no collector, BPI; Boone Co., the Pinnacles, "dead sticks," 26 October 1912, leg. E.J. Durand, CUP-D 9965 (31-43); OHIO: Summit Co., Akron, 450 Spicer St., no date, leg. G.D. Smith, CUP 21886; PENNSYLVANIA: Westmoreland Co., Delmont, December 1985, leg. E. Johnson, CUP 62446; Westmoreland Co., Delmont, February 1986, leg. E. Johnson, CUP 62445; "includes an albino cup," Westmoreland Co., Delmont, November 1989, leg. E. Johnson, CUP 62444; NEW YORK: Tompkins Co., Newfield–Nina Road, 17 April 1952, leg. M.A. Rosinski & R. P. Korf, CUP 38757; Tompkins Co., Upper Enfield, Ithaca, 5 March 1976, R.P. Korf & L.M. Kohn, CUP 54727; Tompkins Co., Six Mile Ck., 8 January 1989, leg. F.A. Harrington, F.A.H. 120; VIRGINIA: Giles Co., Cascades Mts., W. of Pembroke, ele. 2450 ft, "along Little Stony Ck., on fallen branch," 25 Oct 1986, leg. E.Arnolds, F.A.H. 111; WEST VIRGINIA: Nuttallburg, March 1893, leg. L.W. Nuttall, CUP-D 4834 (31-32).

Etymology: The epithet *dudleyi* is in honor of W. R. Dudley, the collector (Peck, 1894).

4. ***Sarcoscypha occidentalis*** (Schw.) Sacc., *Syll. fung.* **8:** 154. 1889. (Figs. 3, 5f, 6a, 11).
≡*Peziza occidentalis* Schw., *Trans. Amer. Philos. Soc.* II **4:** 171. 1832.
≡*Geopyxis occidentalis* (Schw.) Morgan, *Jour. Myc.* **8:**188. 1902.
≡*Plectania occidentalis* (Schw.) Seaver, *North Amer. Cup-fungi (Operculates)* p. 193. 1928.
=*Peziza hesperidea* Cooke & Peck, *Grevillea* **1:** 5. 1872.
≡*Geopyxis hesperidea* (Cooke & Peck) Sacc., *Syll. fung.* **8:** 154. 1889.
= ? *Peziza(Sarcoscyphae) pusio* Berk. & Curt. *in* Berk., *Grevillea* **3:** 153. 1875.
≡ *Sarcoscypha pusio* (Berk. & Curt. *in* Berk.) Sacc., *Syll. fung.* **8:** 155. 1889.

Anamorph: *Molliardiomyces occidentalis* Paden, *Canad. J. Bot.* **62:** 213. 1984.

Apothecium solitary to caespitose, deep cupulate when young, cup-shaped to discoid at maturity, cupulate to cuneiform or linear when dry; predominantly with stipe centrally attached, 5-20 mm in diam, ectal excipulum of stipe of textura porrecta. **Hymenium** bright red, purple red or scarlet (Kornerup and Wanscher, 10A8, 11A8) when fresh, dull scarlet to orange buff (Kornerup and Wanscher, 6A8, 6B7) when dry, margin crenulate and incurved when young, becoming laciniate at maturity. **Stipe** white, composed of parallel cords of hyphal strands, diameter and length corresponding to size and depth that substrate is buried, often reaching a length of 30 mm with a diameter of 1.5-2 mm, deeply twisting and furrowed when dry, long, hyaline, flexuous hyphae often enmeshing detritus. **Receptacle** with opaque tint of the hymenial color when fresh, sparsely tomentose with flexuous hyphae, finely wrinkled when fresh, deeply furrowed with margin strongly incurved when dry, thin-fleshed to rubbery when fresh, becoming leathery when dry, generally glabrous. **Ectal excipulum** of textura porrecta, 20-60 µm thick excluding pustules, cells hyaline, thick-walled, 3-5 µm wide, axes of cells parallel to the outer surface of the apothecium, occasionally light brown isodiametric cells found scattered in clumps on receptacle surface. **Medullary excipulum** of compact textura intricata, hyphae hyaline to subhyaline, running more or

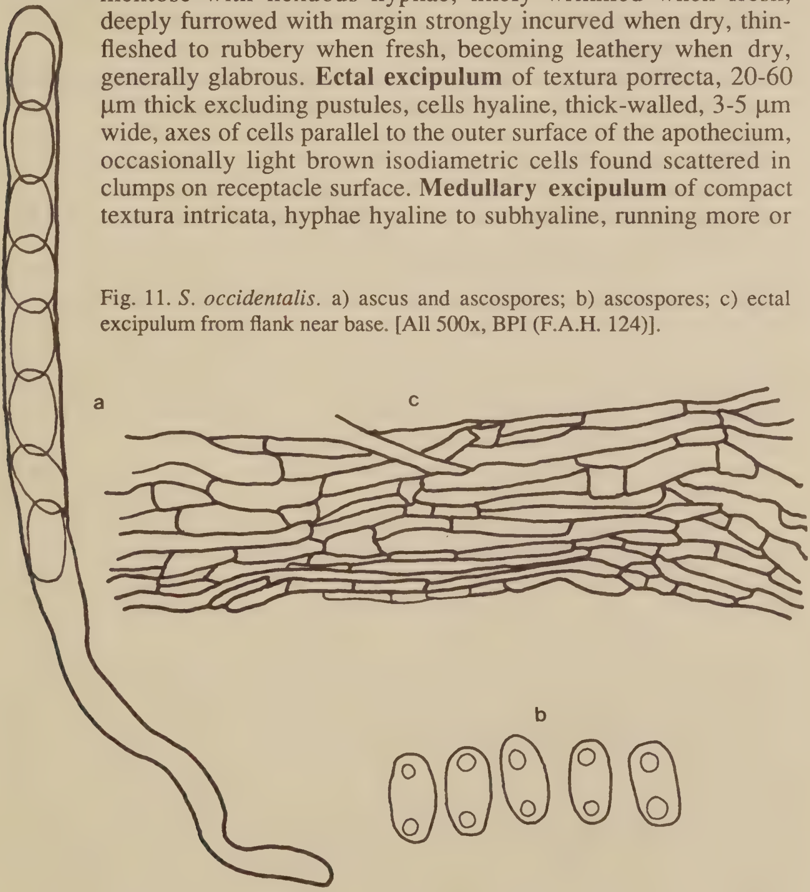

Fig. 11. *S. occidentalis.* a) ascus and ascospores; b) ascospores; c) ectal excipulum from flank near base. [All 500x, BPI (F.A.H. 124)].

less parallel to the outer surface, together with subhymenium 560-750 µm thick. **Asci** long cylindrical, gradually tapering basally, reaching a length of 240-290 (-310) µm with a diameter of 12-16 µm, hyaline, operculum eccentric to terminal. **Ascospores** asymmetrically ellipsoid or broadly ellipsoid, 18-20 × 10-12 µm, apices truncate with bipolar depressions, containing two large polar oil droplets (up to 4 µm), thick-walled, spores sometimes producing conidia when remaining on senescent apothecia, ejected spores sometimes surrounded by mucilaginous sheath. **Paraphyses** narrowing at apex, 1.5-2.5 µm wide, flexuous, branched, septate in lower portion, containing granules of carotenoids, extending slightly past ascus apices.

Holotype: Type collected from Muskingum, Ohio, in August, deposited in PH. Isotype of *Peziza occidentalis*,"part of type ex herb. Schweinitz," no date, no collector, "Syn. Fung. No. 781," [CUP-D 3856 (31-125)].

Type locality: Muskingum, Ohio.

Habitat: shaded areas of deciduous forests on partially buried twigs of trees (e.g., *Acer*) in a moist environment, late spring and summer through early fall.

Distribution: United States: central and southern regions east of the Rocky Mountains.

Other specimens examined: ILLINOIS: Jackson Co., near Murphrysboro, Little Grand Canyon, "solitary on dead buried hardwood sticks," 9 June 1976, leg. H. D. Thiers, SFSU; Johnson Co., Little Black Slough, "solitary to gregarious on dead hardwood sticks," 12 June 1976, leg. H. D. Thiers, SFSU; INDIANA: Brown Co., Hoosier Nat. Forest, "under *Carya ovata* (Miller) K.Koch, Terril Ridge," 31 May 1972, leg. M.B. Tansen, Paden 861 (teleomorph of *Molliardiomyces occidentalis* Paden) UVIC; Turkey Run St. Pk, "air dried,"16 August 1981, leg. K.A. Seifert & J.A. Mackinnon, BPI; IOWA: [Benton Co.], Garrison, 9 July 1905, leg. S.C. Knupp, BPI; [Boone Co.], Ledges State Park, near Ames, "gregarious on wood debris in hardwoods," 25 June 1983, leg. H.D. Thiers, SFSU; KANSAS: Stockton, 11 June 1903, leg. J.E. & E. Bartholomew, BPI; LOUISIANA: [St. Martin Parish], St. Martinsville, "on decaying wood," 11 August 1889, leg. A.B. Langlois, CUP-D 4515 (31-127); MARYLAND: Frederick Co., Catoctin Mtn. Pk., Owens Ck. Campground, 20 June 1973, leg. K.H. McKnight, J.F. Ammirati, M. Pelletier, BPI; Frederick Co., Catoctin Mtn. Pk., "on decaying twigs, near Lantz," 16 July 1976, K.H. & J.B. McKnight, BPI; MICHIGAN: Washtenaw Co.,"on ground" 3d woods S. of Ann Arbor, 2 July 1920 leg. H.M.F. Smith, CUP 30751; NORTH CAROLINA: Wake Co., Raleigh, jct. US 70 and NC 50, "on soil, mixed pine-hardwood forest," 5 Oct 1979, leg. K.H. & V.B.McKnight 16840, BPI; NEBRASKA: Saltillo, "dead wood," no date, CUP-D 10922 (31-154); [Sarpy Co.], Bellevue, 4 July 1894, leg. Pound & Clements, CUP-D 10923 (31-155); NEW YORK: [Kings Co.], Brooklyn, "on sticks in moist place under walnut, 293," 25 July 1912, leg. G. Burlingham, BPI; Tompkins Co.,

SEE ERRATA

Michigan Hollow, 11 September 1986, leg. E. Arnolds, F.A.H. 107; Tompkins Co., Six Mile Ck.,"large numbers growing along path to reservoir," 8 June 1989, leg. F.A. Harrington & D. Potter, F.A.H. 124 (BPI); PENNSYLVANIA: West Chester, label reads: "on decaying pieces of hickory limbs partly buried in the ground, Ellis & Everhart Fungi Columbiani, Syn. N. Am. 781, "N. A. F. 436," July 1895, leg. B.M. Everhart, BPI; Westmoreland Co., Delmont, 29 Apr 1985, leg. E. Johnson, F.A.H. 12; Westmoreland Co., Murrysville, 2 February 1985, leg. E. Johnson, F.A.H. 9; Westmoreland Co., Murrysville, Duff Nature Park, 29 July 1985, leg. E. Johnson, CUP 62454; TEXAS: Houston Co., Davy Crockett Nat'l Forest near Ratcliff, "gregarious on dead sticks in mixed open woods," (no date) leg. H.D. Thiers 5896, SFSU; VIRGINIA: Warren Co., Shenandoah Nat. Pk., "near top of mt. along trail to Compton's Lookout on buried sticks in mixed hardwoods," 12 July 1986, leg. M. Hunt & A. Murray, F.A.H. 59; Giles Co., Jefferson Nat. Forest, Bailey Gap on Butt Mtn., "scattered, emerging from leaf litter either from small buried sticks," 12 June 1983, G. Bills, BPI.

Etymology: The epithet *occidentalis* is a Latin adjective for western.

Excluded and doubtful taxa

The following list contains excluded and doubtful taxa described from or reported to occur in the new world (esp. North America).

1. *Sarcoscypha albovillosa* Rehm, *Ann. Mycol.* **2:** 33. 1904.

Seaver (1928) included this species as a synonym of *Aleuria rutilans* (Fries) Gill., *Champ. Fr. Discom.* 53. 1879. According to Pfister (1982) this species is *Leucoscypha rutilans* (Fr.) Dennis & Rifai *in* Rifai, *Verh. Kon. Akad. Wetensch., Afd. Natuurk., Tweede Sect.*, **57**(3): 164. 1968.

2. *Sarcoscypha alphitodes* (Berk.) Sacc., *Syll. fung.* **8:** 158. 1889.

≡ *Peziza (Sarcoscyphæ) alphitodes* Berk., *Grevillea* 3: 153. 1875.

White (in litt.) according to Pfister (1979b) cites this as *Leucoscypha albo-cincta* (Fr. : Fr.) Bres., *Ann. Mycol.* **1**: 121. 1903. Type locality: Boston, Massachusetts.

3. *Sarcoscypha alpina* Ellis & Ev., *Bull. Torrey Bot. Club* **24:** 281. 1897.

According to Seaver (1928) this is *Plectania hiemalis* (Nees & Bernst.) Seaver which Kanouse (1948) later listed as a synonym of *Microstoma protracta* (Fr.) Sacc. Type locality: Nederland, Colorado.

4. *Sarcoscypha carminea* Pat., *Bull. Soc. Mycol. France* **15:** 205. 1899.

≡ *Phillipsia carminea* (Pat.) Le Gal, *Bull. Jard. Bot. État* **29**: 103. 1959.

Denison (1969) agrees with Le Gal's treatment. Type locality:

SEE ERRATA

Guadelope.

5. *Sarcoscypha colensoi* (Berk.) Saccardo ('Colensoi'), *Syll. fung.* **8**: 157. 1889.
≡ *Peziza colensoi* Berkeley, Hooker's *Fl. nov.-zel.* **2:** 200. 1855.
≡ *Cookeina colensoi* (Berk.) Seaver, *Mycologia* **5**: 191. 1913.

According to Korf (1971) this is *Boedijnopeziza colensoi* (Berk.) Korf & Erb, *Phytologia* **21**: 201-207.

6. *Sarcoscypha concatenata* Rick, *Brotéria* **5:** 32. 1906. Type locality: São Leopoldo, Brazil, on *Pinus*.

According to Dennis (1960) the type material contains inadequate hymenial material to support whether on not this is a new species.

7. *Sarcoscypha corium* (Weberb.) Schroet., *Krypt.-Fl. Schlesien* **3**(2): 59. 1893.
≡ *Peziza corium* Weberb. *Pilze Nord-Deutsch.* **1:** 7, pl. 3, fig. 7. 1873.
≡ *Helvella corium* (Weberb.) Massee, *Brit. fung.-fl.* **4:** 463. 1895.

I follow Dissing (1966) in assigning this species to *Helvella.*

8. *Sarcoscypha cruciata* (Fr.) Sacc., *Syll. fung.* **8**: 158. 1889.
≡ *Peziza cruciata* Fr., *Nov. symb. mycol.* 229. 1851.

Seaver (1928) listed this species as a synonym of *Plectania hiemalis* (Nees & Bernst.) Seaver. According to Kanouse (1948) this is *Microstoma protracta* (Fr.) Kanouse, *Mycologia* **40**: 486. 1948.

9. *Sarcoscypha dawsonensis* Peck, *Bull. Torrey Bot. Club* **33**: 220. 1906.

Pfister (1982) agrees with Seaver's placement of this species as a synonym of *Geopyxis vulcanalis* (Peck) Sacc., *Syll. fung*. **8**: 65. 1889. Type locality: West Dawson, Yukon Terr.

10. *Sarcoscypha floccosa* (Schw.) Sacc., *Syll. fung.* **8**: 156, 1889.
≡ *Peziza floccosa*, Schw., *Trans. Amer. Philos. Soc.* II **4:** 172. 1832.

I agree with Raitviir (1965) that this is a synonym of *Microstoma floccosum* (Schw.) Raitv. (*'floccosa'*). Type locality: Nazareth, Pennsylvania.

11. *Sarcoscypha imperialis* (Peck) Saccardo, *Syll. fung.* **8**: 157. 1889.
≡ *Peziza imperialis* Peck, *Annual Rep. New York State Mus.* **29**: 54. 1878, non *Peziza imperialis* Beck 1884.
≡ *Sowerbyella imperialis* (Peck) Korf, *Phytologia* **21**(4): 206. 1971.

I accept this name in *Sowerbyella* following Moravec (1985a). Type locality: Greig, [NY].

SEE ERRATA

12. *Sarcoscypha melastoma* (Sow. : Fr.) Rehm, *Rabenh. Krypt.-Fl. ed. 2* [Lief. 44]: 1070. 1895.
≡*Peziza melastoma* Sow., *English fungi,* t. 149. 1799 : Fr., *Syst. mycol.* **2:** 80. 1822.
≡*Plectania melastoma* (Sow. : Fr.) Fuckel, *Jahrb. Nassauischen Vereins Naturk.* **23-24:** 324. 1870.

In Paden's (1983) monograph of the Sarcosomataceae he follows Fuckel's (1870) decision to place this species in the genus *Plectania*, as do I.

13. *Sarcoscypha hiemalis* (Fr.) Sacc., *Syll. fung.* **8**: 155. 1889.

Seaver (1928) listed this species as a synonym of *Plectania hiemalis* (Nees & Bernst.) Seaver. Kanouse (1948) later referred this species to *Microstoma protracta* (Fr.) Kanouse, which I accept.

14. *Peziza pulcherrima* Raf., *Med. Repos.* **2** (5): 362. 1808.

Seaver (1928) lists this as a synonym of *Plectania coccinea*. The description of this taxon (Rafinesque, 1808) is too vague to associate with any species in *Sarcoscypha*. Type locality : Pennsylvania.

15. *Sarcoscypha pusio* (Berk. & Curt. *in* Berk.) Sacc., *Syll. fung.* **8:** 155. 1889.
≡*Peziza (Sarcoscyphae) pusio* Berk. & Curt. *in* Berk., *Grevillea* **3**: 153. 1875.

I have not been able to examine any authentic specimens of this taxon. Pfister (1979b) says it is a small specimen of *S. occidentalis*. Type locality: Texas.

16. *Sarcoscypha racovitzae* Bommer & Rousseau, *Bull. Acad. Roy. Sci. Belgique, Cl. Sci.,* Sér. 3, **38:** 643. 1900.

Gamundí (1975) lists this species with those insufficiently known. Type locality: Beagle Canal, Tierra del Fuego, Argentina.

17. *Sarcoscypha radiculata* (Sow.) Sacc., *Syll. fung.* **8**: 156. 1889.
≡*Peziza radiculata* Sow. *English fungi,* p. 192, pl. 114. 1797.

According to Moravec (1985a, b) this is *Sowerbyella radiculata* (Sow.) Nannf., *Svensk Bot. Tidskr.* **32:** 118. 1938.

18. *Sarcoscypha rhenana* (Fuckel) Sacc., *Syll. fung.* **8**: 157. 1889.
≡*Aleuria rhenana* Fuckel, *Jahrb. Nassauischen Vereins Naturk.* **23-24**: 325. 1870.
≡*Sowerbyella rhenana* (Fckl.) Moravec, *Mycol. Helvet.* **2**(1): 96. 1986.

I accept Moravec's (1986) disposition of this species.

19. *Sarcoscypha roseotincta* Clements, *Bot. Surv. Nebr.* **4:** 11. 1896.

Pfister's (1978) studies of Clements's *Peziza* types did not include this species. I have examined isotype material (CUP-D 10920) and it does not belong in the genus *Sarcoscypha,* but I am not prepared to place it generically. Type locality: Nebraska.

20. *Sarcoscypha striispora* (Ell. & Ev.) Sacc. & Sydow, *Syll. fung.* **14**: 754. 1899.
≡ *Peziza striispora* Ell. & Ev., *Bull. Iowa Univ. Lab. Nat. Hist.* **4:** 69. 1896.

I treat this as *Cookeina tricholoma* (Mont.) Kuntze, in accordance with Boedijn (1933) and Pfister (1978).

21. *Sarcoscypha tetraspora* (Seaver) Denison, *Revista Biol. Trop.* **11**: 107. 1963.
≡ *Cookeina tetraspora* Seaver, *Mycologia* **17**: 45. 1925.
≡ *Phillipsia tetraspora* (Seaver) Le Gal, *Les Discomycètes de Madagascar* p. 262. 1953.
≡ *Nanoscypha tetraspora* (Seaver) Denison, *Mycologia* **64**: 609-623. 1964.

I accept the last disposition by Denison (1964).

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TAXONOMIC REVISION OF THE GENUS CHEILYMENIA - 3. A NEW GENERIC AND INFRAGENERIC CLASSIFICATION OF CHEILYMENIA IN A NEW EMENDATION.

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ABSTRACT

A new generic and infrageneric classification of the genus *Cheilymenia* Boud. emend. nov. is proposed. The genus *Cheilymenia*, which in this new emendation includes also the genus *Coprobia* Boud., is divided into the following sections and series:
Sect. 1. *Coprobiae* comb. et stat. nov.; sect. 2. *Striatisporae* sect. nov. with ser. a. *Striatisporae* and ser. b. *Tenuistriatae* ser. nov.; sect. 3. *Villosae* sect. nov. with ser. a. *Villosae* and ser. b. *Obtusipilosae* ser. nov.; sect. 4. *Micropilosae* sect. nov.; sect. 5. *Paracheilymeniae* sect. nov. ; sect. 6. *Insigniae* sect. nov.; sect. 7. *Raripilosae* sect. nov.; sect. 8. *Cheilymenia* with ser. a. *Cheilymenia* and ser. b. *Pallidae* ser. nov.; sect. 9. *Pseudoscutelliniae*, sect. nov. with ser. a. *Pseudoscutelliniae*, ser. b. *Coprinariae* ser. nov., and ser. c. *Fuscae* (Svr.) comb. et stat. nov.
The paper comprises also a synopsis of the infrageneric classification with 33 accepted species, diagnoses, illustrations including SEM photomicrographs, new combinations and a list of excluded taxa and synonyms.

INTRODUCTION

The genus *Cheilymenia*, erected by Boudier (1907) and accepted by many recent authors, has been also considered to be a complex of several genera as discussed recently (J.Moravec 1984,1987,1989a; Pfister 1988). The variations in anatomy of apothecia and types of hairs were previously treated by Denison (1964). It should be noted that *Cheilymenia theleboloides* (Alb. et Schw.) Boud. sensu Denison (1964) is *Kotlabaea deformis* (Karst.) Svr. and the neotype (Leipzig, May 1884 leg. Winter, CUP-D, issued as Rehm's Ascomyceten No 604c) selected by Denison is untenable.

As a result of the examination of relevant types and other material, the presence of hyphal outgrowths on the ectal excipulum of species of *Coprobia* Boud., including the type species, *C. granulata* (Bull.) Boud., has been noted (J.Moravec 1987). Due to the anatomical similarity between apothecia of *C. theleboloides*, which bear hyphoid to acuminate but superficial hairs arising from the excipular cells, and those of *Coprobia*, I concluded that there was no basic character distinguishing these two genera. Consequently, I proposed the transfer (J.Moravec 1987) of *C. theleboloides* to the genus *Coprobia*, and later (J.Moravec 1988) made a new emendation of the genus *Coprobia*. This opinion was supported by the ascospore perisporium both in species of *Coprobia* and in *Cheilymenia*

theleboloides possessing a similar cyanophilic longitudinal striation, which was also proved by SEM studies.
Furthermore, in the course of this revision, many differences were observed between other species of Cheilymenia, which might have been considered basic features for generic delimitation. Several species related to Cheilymenia coprinaria (Cooke) Boud. are very similar to species of the genus Scutellinia (Fr.) Lamb., especially to those which are referred to the sections Minutae Svr. and Pseudocheilymeniae Svr. This similarity is particularly evident in excipular structure, type of hairs, and separable perisporium. A group of species related to Cheilymenia rubra (Cooke ex Phill.) Boud. was recently discussed (J.Moravec 1989a).This group is distinguished by the anatomy of the apothecia, in which the excipulum is clearly differentiated into an ectal layer composed of textura globulosa-angularis and a medullary layer composed of textura intricata. Moreover, their marginal hairs are rigid and rooting, with a simple or multifurcate base, arising deeply in the excipular tissue. Finally, the ascospore perisporium is covered by cyanophilic pustules, warts or crests, as shown also by SEM studies. This group of species is, therefore, distinct from others of the genus Cheilymenia and Coprobia as interpreted previously (J.Moravec 1988). Again, several species of Cheilymenia, e.g. Cheilymenia raripila (Phill.) Dennis and other similar species with extremely small apothecia which resemble those of the genus Lasiobolus, appeared generically different from, for example C. coprinaria and its allies. Also, several other species, including the type species of the genus, Cheilymenia stercorea, possess features which are distinct from those of species mentioned above.
However, further examination revealed several species of Cheilymenia which exhibit features of one or all groups discussed above. Therefore, a dilemma arose: **either to erect several new genera (some of them monotypic) or to maintain a single large genus**, which would include, however, also all species of the genus Coprobia. The first solution would seem to be inhibited by the fact that many features of value for generic delimitation occur in several species of different groups, which, on the contrary possess features of other groups too. I have , therefore, decided to adopt the **second solution**. This is partly in accordance with Rifai's opinion. Rifai (1968) has previously discussed this problem and expressed his opinion to recognize infrageneric taxa only after the characters of all species of the genus Cheilymenia would be fully understood.
The conception of the single large genus is supported especially by the following features:

1. The type species of Coprobia, C. granulata, has apothecia with a textura globulosa-angularis virtually throughout. However, hyphal elements occasionally occur in the medullary layer. Such hyphoid cells and inflated hyphae are more commonly presented in the excipulum of Cheilymenia theleboloides.

2. The hyaline hyphal outgrowths on the ectal excipulum of Coprobia granulata and all other species of Coprobia are similar to the hyaline hyphae and hyphoid hairs of C. thele-

boloides, although the latter possesses not only hyaline hyphoid superficial hairs with a bulbous base, but also yellowish acuminate superficial hairs with "germs" of roots. The latter consist usually of a bifurcate base of bulbous "primitive germs of roots". However, apothecia of many collections of C. theleboloides possess only hyphoid hairs and lack the acuminate yellowish hairs, or these hairs occur very rarely. After examination of many apothecia from various collections of C. theleboloides, I found apothecia having both types of hairs,and apothecia with absence of acuminate hairs. There are also many intermediate forms of these hairs, from hyaline hyphoid hairs to subhyaline or yellowish acuminate hairs with walls 0.2-2.5 µm thick in this variable species. The acuminate hairs may have the base bulbous and simple,or developed into bifurcate,rounded germs of the primitive roots. In other species of this group the hairs bear both bulbous, divided,and primitively rooting bases.

3. As well as those species with the combination of typically rooting hairs and well differentiated excipulum, there are several species with superficial hairs, which also have the excipulum more differentiated (with the medullary layer of textura subintricata to intricata). Moreover, their ascospore perisporium may have cyanophilic longitudinal striation (e.g. Cheilymenia lemuriensis Heim in Le Gal).

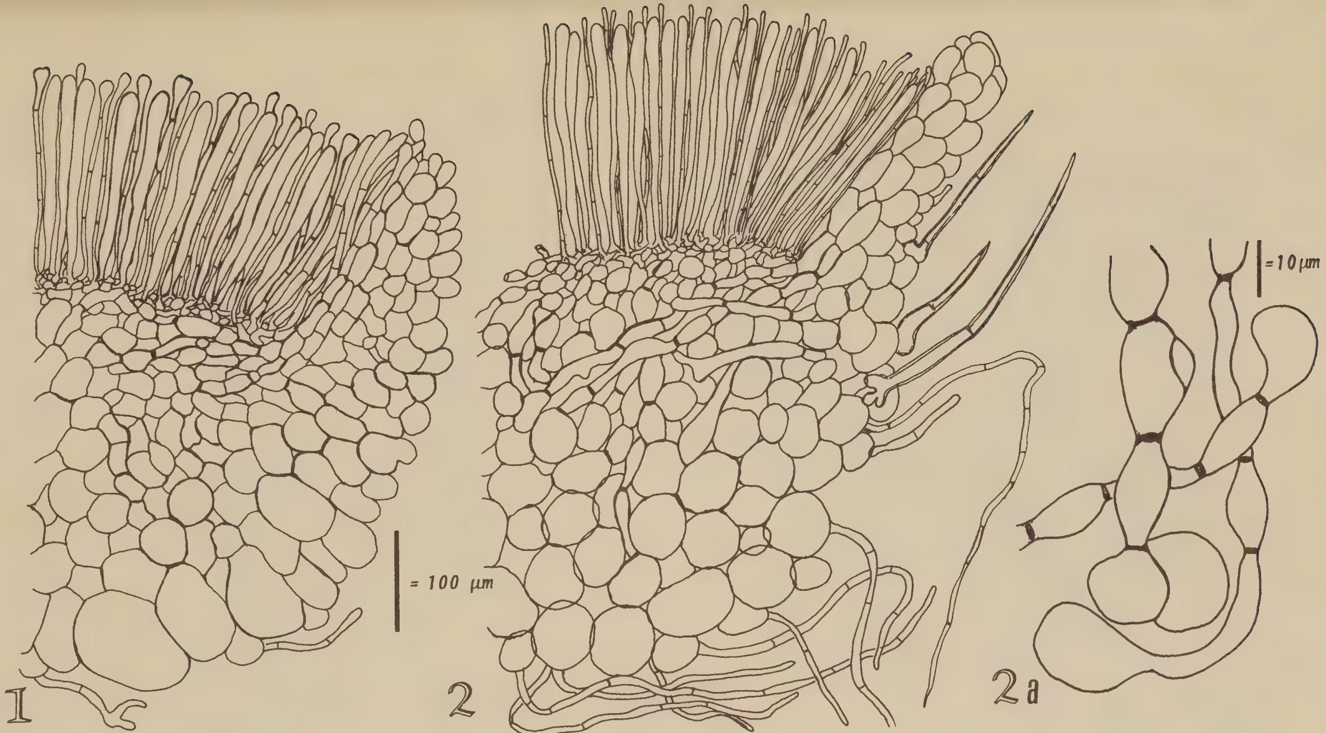
4. Longitudinal ascospore striation was previously considered a typical feature of species with simple anatomy and superficial hairs (Coprobia in my previous emendation).
However, a fine longitudinal striation has been recently found and proved by SEM also on the perisporium of ascospores of Cheilymenia oligotricha (Karst.) J.Mor. (= Cheilymenia vitellina (Pers.) Dennis - a nomen dubium), Cheilymenia citrinella (Velen.) Svr. and Cheilymenia pediseta (Clements) J.Mor. However, in contrast to the simple excipulum of Coprobia and Cheilymenia theleboloides, the excipulum of C. oligotricha, C. citrinella and C. pediseta is more differentiated: the medullary layer is of textura subintricata to almost typical textura intricata and the ectal layer of textura globulosa-angularis. These three species possess hairs of several types: superficial hairs with simple, bifurcate or multifurcate tuberous to multituberous base, rooting hairs with only germs of bulbous roots, and almost typical, rooting, long, broad, rigid marginal hairs with multifurcate base. Hyaline hyphae and intermediate forms of hairs are present as well as the rooting hairs in each apothecium. Therefore, due to the ascospore striation and the variable and intermediate forms of excipulum and hairs, as well as the similar yellow apothecia, these species must be considered congeneric with C. theleboloides. Despite the differences in excipulum and marginal hairs, the relationship is evident.
There are several other results which support this decision. These will be presented and discussed, together with descriptions and drawings of all individual taxa in future papers. A monograph of the genus is currently in preparation. I am convinced that the examples treated above sufficiently support the decision to reject my previous emendation of the genus Coprobia. It is inappropriate to erect subgenera as the features are too intermediate and combined with various features which occur in other groups.

A SYNOPSIS OF THE INFRAGENERIC CLASSIFICATION OF CHEILYMENIA

Cheilymenia Boud. em. J.Mor.

- sect. 1. *Coprobiae*
    - *C. granulata* (Bull.) J.Mor.
    - *C. sordida* (J.Mor.) J.Mor.
    - *C. striata* (Thind,Cash et Singh) J.Mor.
    - *C. crassistriata* (J.Mor.) J.Mor.
    - *C. karstenii* J.Mor.
- sect. 2. *Striatisporae*
    - ser. a. *Striatisporae*
        - *C. theleboloides* (Alb.et Schw.)Boud.
        - *C. lemuriensis* Heim in Le Gal
    - ser. b. *Tenuistriatae*
        - *C. oligotricha* (Karst.)J.Mor.
        - *C. citrinella* (Velen.) Svr.
        - *C. pediseta* (Clem.) J.Mor.
- sect. 3. *Villosae*
    - ser. a. *Villosae*
        - *C. villosa* Gamundí
        - *C. gemella* (Karst.) J.Mor.
    - ser. b. *Obtusipilosae*
        - *C. magnifica* (W.-y.Zhuang et Korf)J.Mor.
- sect. 4. *Micropilosae*
    - *C. stercoraria* (Velen.) J.Mor.
- sect. 5. *Paracheilymeniae*
    - *C. pulcherrima* (Crouan et Crouan) Boud.
    - *C. aurantiacorubra* Thind et Kaushal
- sect. 6. *Insigniae*
    - *C. insignis* (Crouan et Crouan) Boud.
- sect. 7. *Raripilosae*
    - *C. raripila* (Phill.) Dennis
    - *C. coprogena* (Berk.et Br.) Rifai
    - *C. bohemica* (Velen.) J.Mor.
- sect. 8. *Cheilymenia* sect. typica
    - ser. a. *Cheilymenia*
        - *C. stercorea* (Fr.) Boud.
        - *C. asteropila* J.Mor.
    - ser. b. *Pallidae*
        - *C. pallida* Bell.et Dennis
- sect. 9. *Pseudoscutelliniae*
    - ser. a. *Pseudoscutelliniae*
        - *C. rubra* (Cooke ex Phill.) Boud.
        - *C. humarioides* (Rehm) Gamundí
        - *C. pseudohumarioides* Diss.,J.Mor. et Siv.
        - *C. fimicola* (de Not.et Bagl.) Dennis
        - *C. liskae* J.Mor.,Fell.et Landa
        - *C. fraudans* (Karst.) Boud.
    - ser. b. *Coprinariae*
        - *C. coprinaria* (Cooke) Boud.
        - *C. magnipila* J.Mor.
        - *C. megaspora* (Gamundí) J.Mor.
    - ser. c. *Fuscae*
        - *C. cadaverina* (Velen.) Svr.

Note:
Several imperfectly known or critical species are not included here.



Figs.1-2. Apothecial structures of *Cheilymenia* -sections of the marginal part of apothecia: **1**. Sect. Coprobiae, *C. granulata* (Bohemia,Branžež,21.VIII.1966,J.Mor.); **2**. Sect. *Striatisporae* ser. *Striatisporae*, *C. theleboloides* (Moravia,Adamov,8.X.1989,J.Mor.); **2a**. Cells and occasional inflated hyphae with strongly cyanophilic septa of the medullary excipulum of *C. theleboloides*. Note that similar hyphal elements occur much more rarely in the medulla of *C. granulata* (sect.*Coprobiae*).

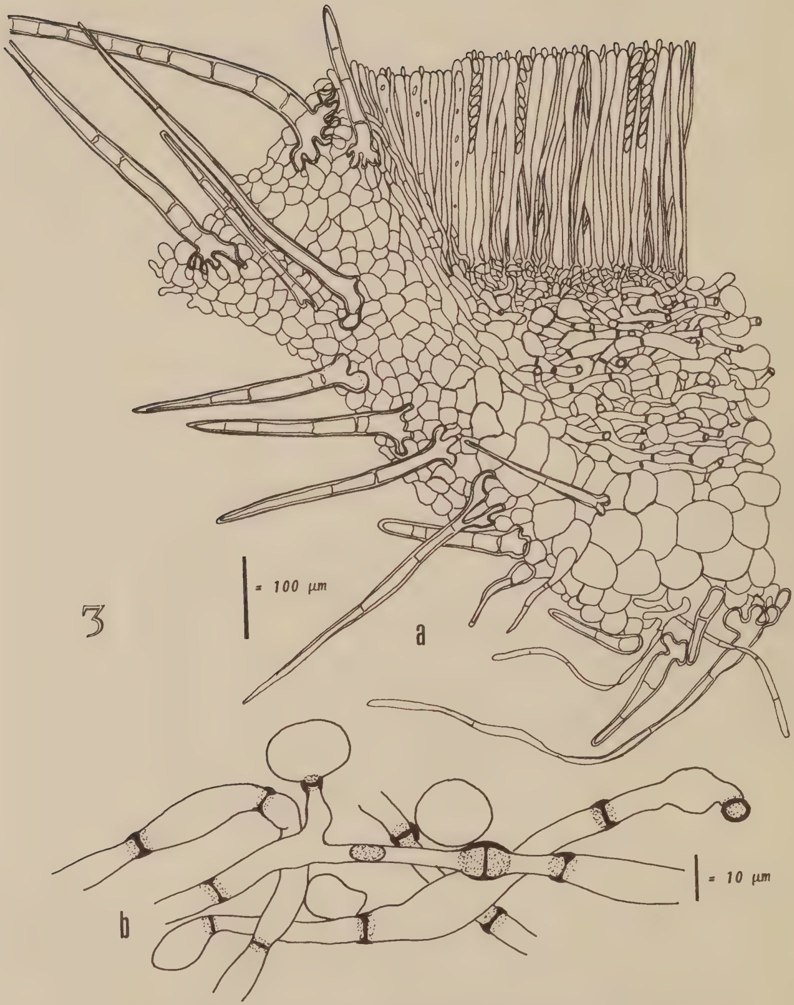
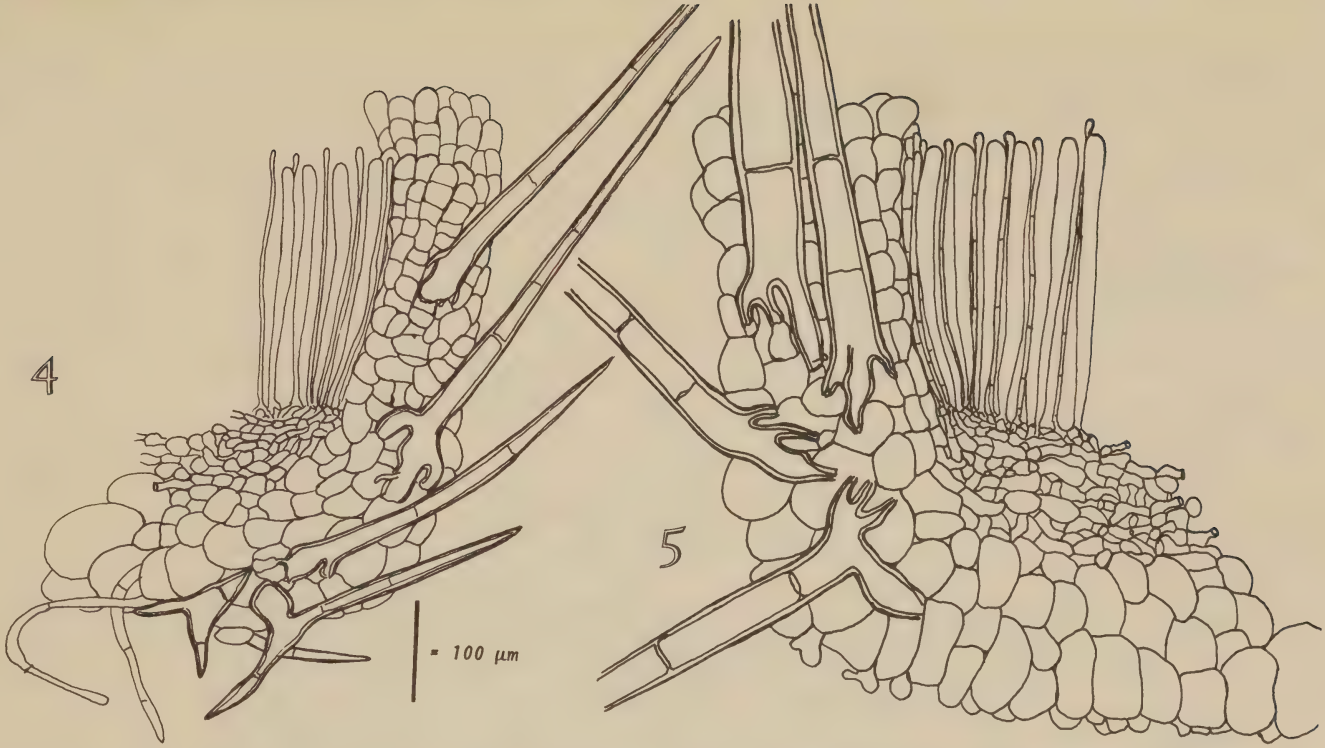
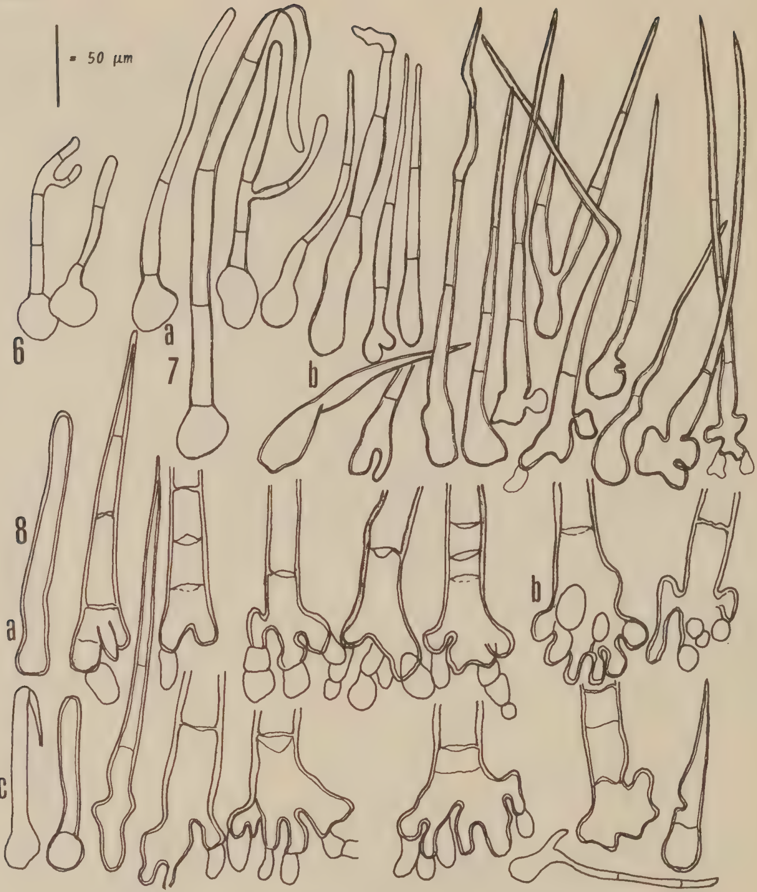


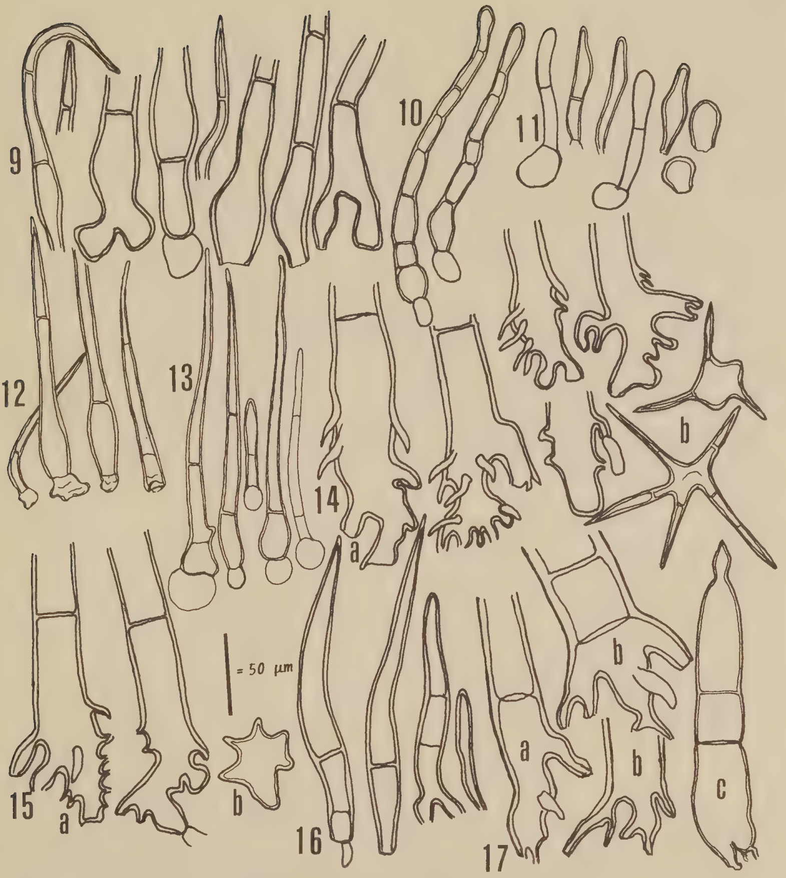
Fig.**3**. Apothecial structures of Cheilymenia, sect. Striatisporae ser. Tenuistriatae: **a**. section through the marginal part of an apothecium of C. oligotricha (Moravia, Adamov,IX.1988)- note medullary excipulum composed of a textura subintricata to almost intricata; **b**. hyphae of the medullary excipulum -note strongly cyanophilic septa.



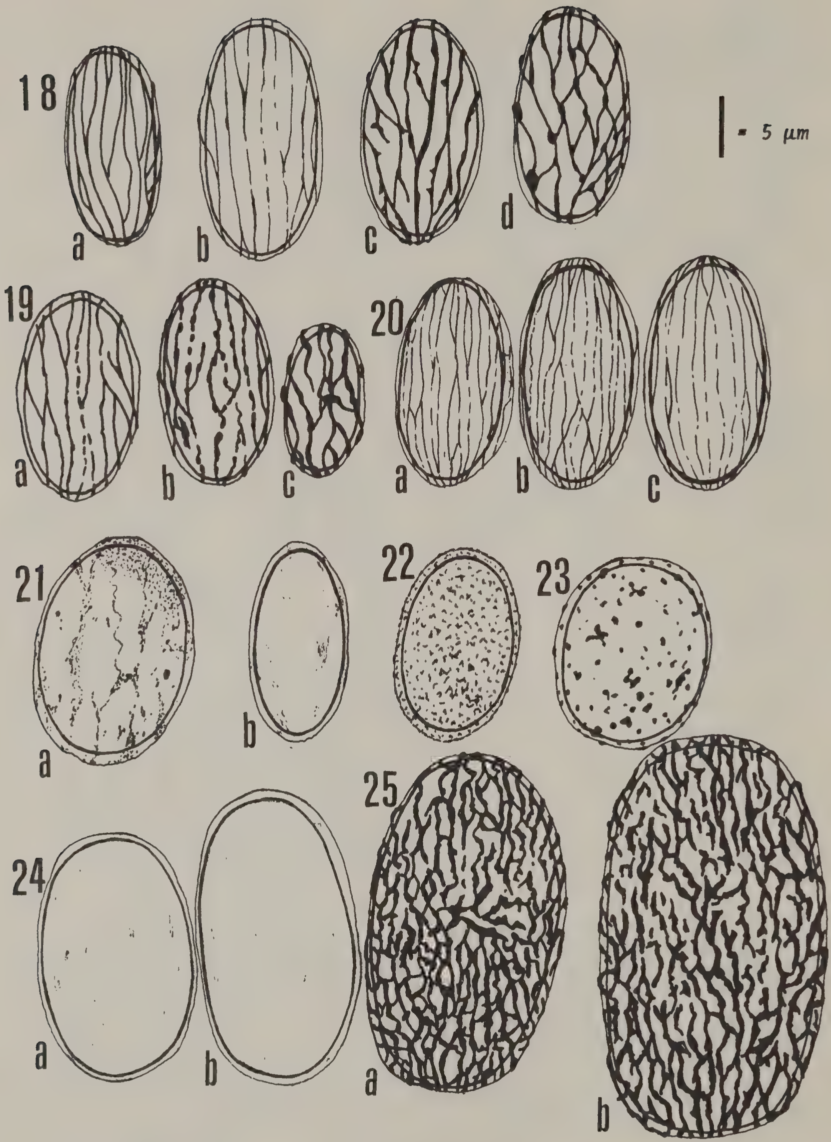
Figs.4-5. Apothecial structures of *Cheilymenia*: 4. Sect. *Cheilymenia* ser. *Cheilymenia* - section of the marginal part of an apothecium of *C. stercorea* (Bohemia,Branžež,20.III.1967,J.Mor.); 5. Sect. *Pseudoscutelliniae* ser. *Pseudoscutelliniae* - section through the marginal part of an apothecium of *C. magnipila* (isotype J.Mor.)



Figs. **6-8**. Hairs of *Cheilymenia*: **6**. Sect. *Coprobiae*- hyphoid hairs of *C. granulata* (Bohemia,Branžež,21.VIII.1966,J.Mor.); **7**. Sect. *Striatisporae* ser. *Striatisporae*, *C. theleboloides*: **a**. hyphoid to subacuminate superficial hairs, **b**. subacuminate to acuminate superficial hairs with simple to bifurcate, rarely multifurcate but bulbous base. Note primitive germs of roots (PRM 603969); **8**. Sect. *Striatisporae* ser. *Tenuistriatae*: **a**. superficial hairs with bulbous base and marginal rooting hairs with obtusely multifurcate base of *C. citrinella* (holotype PRM), **b**. multifurcate tuberous base of hairs of *C. pediseta* (type NY), **c**. superficial hairs with bulbous base, and marginal rooting hairs with bulbous to obtusely multifurcate base of *C. oligotricha* (holotype H).



Figs.**9-17**. Hairs of *Cheilymenia*: **9**. Sect. *Villosae* ser. *Villosae*, *C. villosa* (holotype LPS); **10**. Sect. *Villosae* ser. *Obtusipilosae*, *C. magnifica* (isotype HMAS); **11**. Sect. *Micropilosae*, *C. stercoraria* (Holotype PRM); **12**. Sect. *Paracheilymeniae*, *C. pulcherrima*(isotype PC); **13**. Sect. *Raripilosae*: *C. raripila* (holotype K); **14**. Sect. *Cheilymenia* ser. *Cheilymenia*: **a**. multifurcate to coralloid rooting base of marginal hairs of *C. stercorea* (Bohemia,Branžež,20.III.1967), **b**. stellate receptacular hairs of *C. stercorea*; **15**. Sect. *Cheilymenia* ser. *Pallidae*, *C. pallida*: **a**. base of marginal hairs, **b**. cells of a stellate shape but not developed to hairs(isotype,J.Mor.); **16**. Sect. *Pseudoscutelliniae* ser. *Pseudoscutelliniae*, *C. rubra* (holotype K); **17**. Sect. *Pseudoscutelliniae* ser. *Coprinariae*: **a**.base of a hair of *C. coprinaria* (holotype K), **b**. base of hairs of *C. magnipila* (isotype J.Mor.), **c**. *C. cadaverina* (holotype PRM).



Figs. **18-30**. Ascospores of Cheilymenia stained with CB (without heating the slides) under oil immersion: **18**. Sect. Coprobiae: **a**. C granulata (type of Humaria granulata var. robusta, S.); **b**. C. karstenii(type H), **c**. C. crassistriata (isotype J.Mor.), **d**. C. sordida (isotype J.Mor.); **19**. Sect. Striatisporae ser. Striatisporae: **a**. C. theleboloides (Moravia,Adamov,8.X.1989,J.Mor.), **b**. C. theleboloides (type of Peziza vinacea S), **c**. C. lemuriensis

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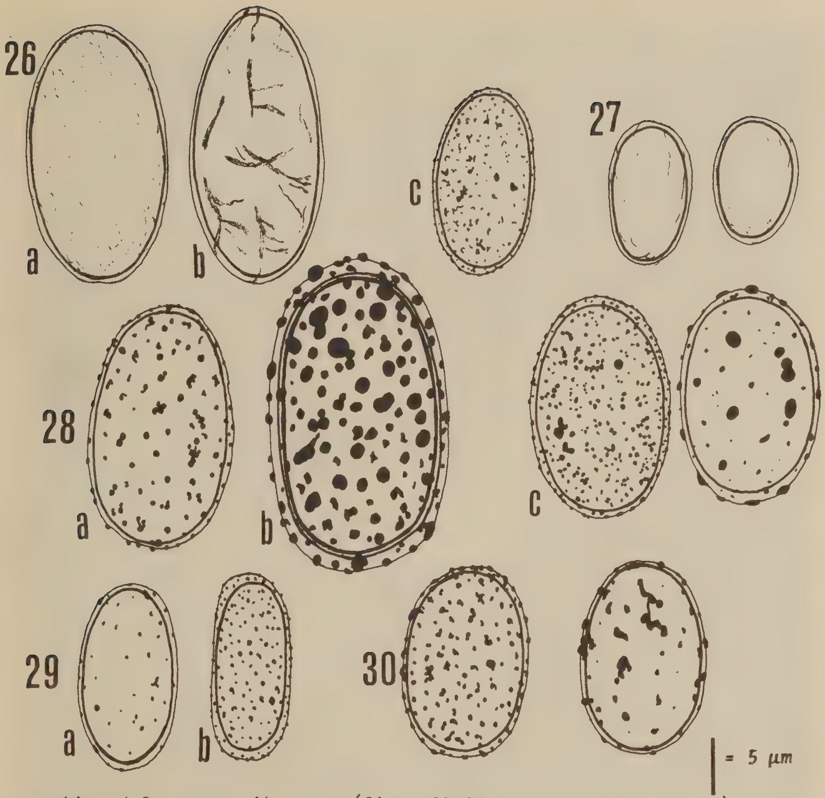
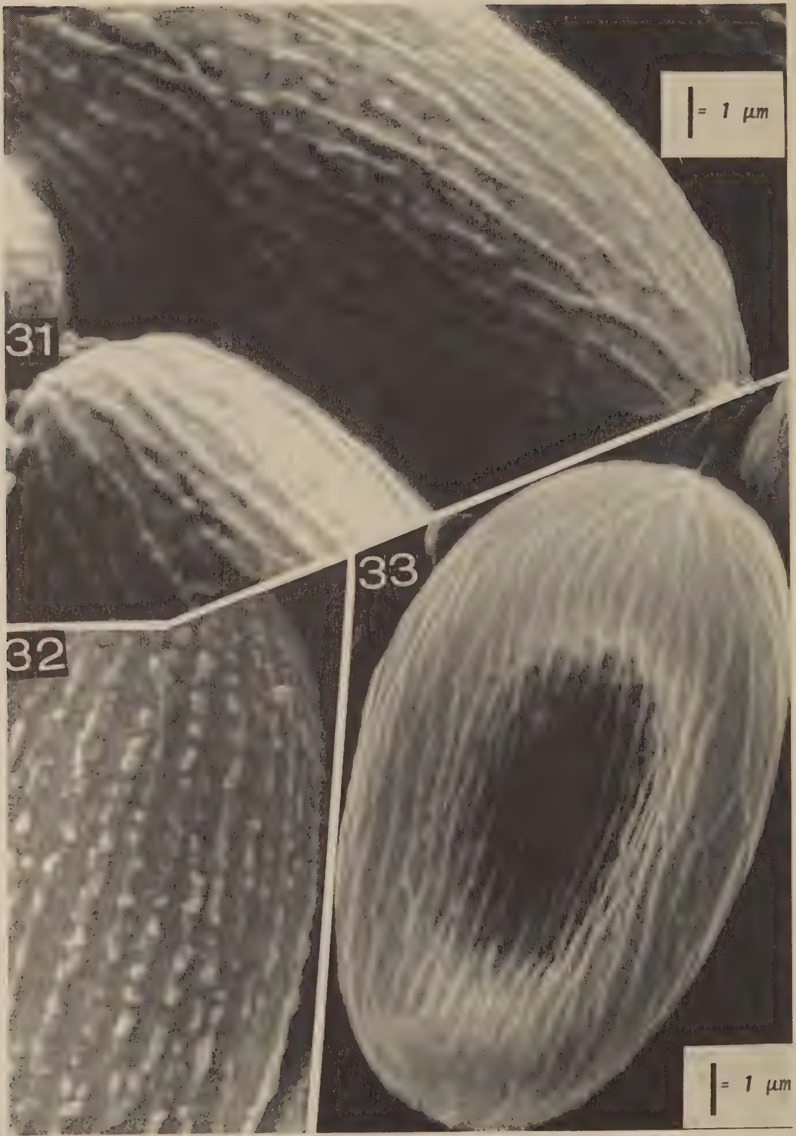
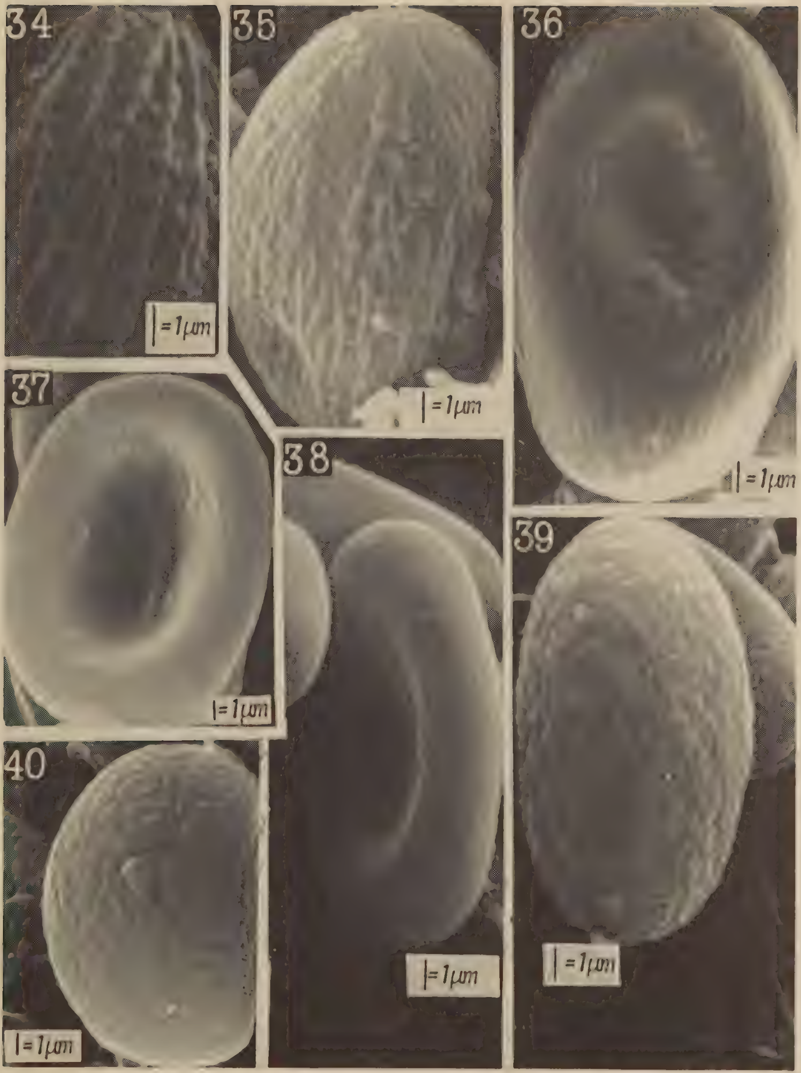
Page 469 line 17 for Arhenia read Arrhenia



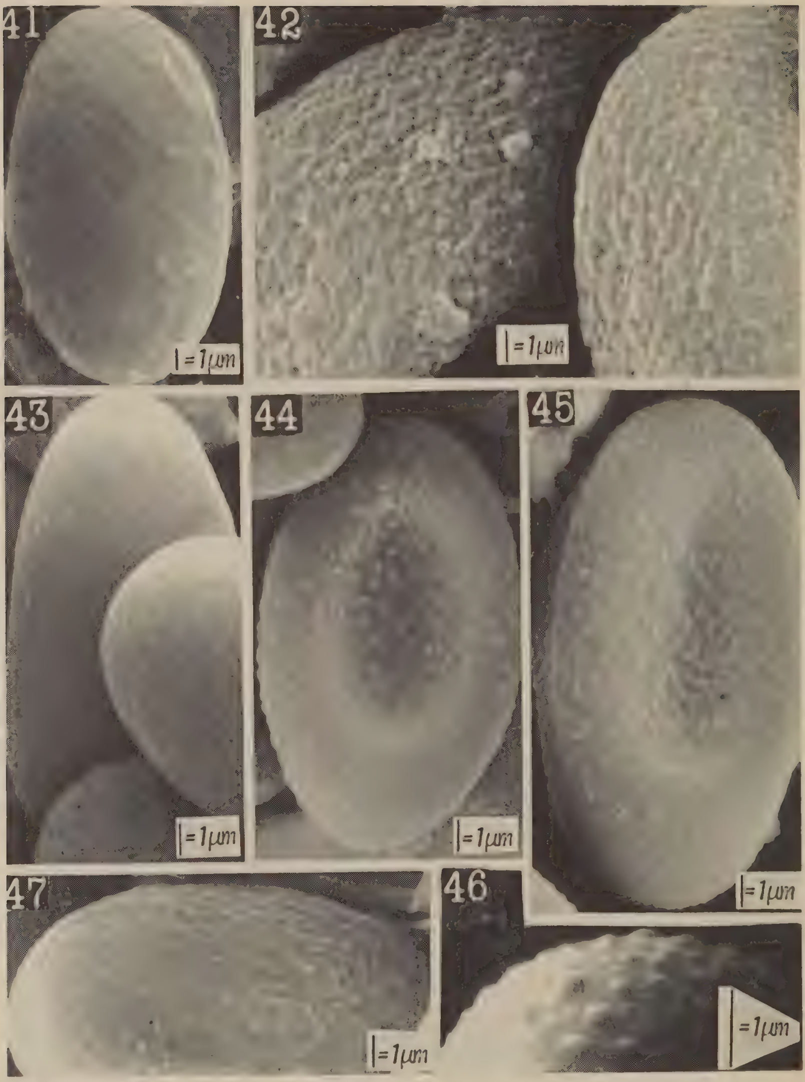
continued from opposite page (figs. 20–25 see on opposite page). (holotype PC); **20**. Sect. *Striatisporae* ser. *Tenuistriatae*: **a**. *C. oligotricha* (Holotype H), **b**. *C. pediseta* (type NY), **c**. *C. citrinella* (holotype PRM); **21**. Sect. *Villosae* ser. *Villosae*: **a**. *C. villosa* (holotype LPS), **b**. *C. gemella* (holotype H); **22**. Sect. *Villosae* ser. *Obtusipilosae*, *C. magnifica* (isotype HMAS); **23**. Sect. *Micropilosae*, *C. stercoraria* (holotype PRM); **24**. Sect. *Paracheilymeniae*: **a**. *C. aurantiacorubra* (isotype BRA), **b**. *C. pulcherrima* (isotype PC); **25**. Sect. *Raripilosae*: **a**. *C. raripila* (holotype K), **b**. *C. coprogena* (holotype K); **26**. Sect. *Cheilymenia* ser. *Cheilymenia*: **a**. *C. stercorea* (type of *Peziza scubalonta*, K), **b**. *C. stercorea* (Branžež,20.III.1967,J.Mor.); **c**. *C. asteropila* (holotype BRA); **27**. Sect. *Cheilymenia* ser. *Pallidae*, *C. pallida* (isotype J.Mor.); **28**. Sect. *Pseudoscutelliniae* ser. *Pseudoscutellinae*: **a**. *C. rubra* (holotype,K); **b**. *C. humarioides* (holotype, LPS), **c**. *C. fimicola* (type of *Arhenia fimicola*, UPS); **29**. Sect. *Pseudoscutelliniae* ser. *Coprinariae*: **a**. *C. coprinaria* (holotype,K), **b**. *C. magnipila* (isotype J.Mor.); **30**. Sect. *Pseudoscutelliniae* ser. *Fuscae*, *C. cadaverina* (holotype PRM).



Figs.31-33. SEM of ascospores of Cheilymenia sect. Striatisporae: 31-32. Ser. Striatisporae: 31. C. theleboloides (8.X. 1989,J.Mor.); 32. C. theleboloides (type of Peziza vinacea,S); 33. Ser. Tenuistriatae, C. oligotricha (Adamov,IX.1988,J.Mor.).



Figs.**34-40**. SEM of ascospores of *Cheilymenia*: **34**.Sect. *Coprobiae*, *C.crassistriata* (isotype,J.Mor.); **35-36**. Sect. *Striatisporae*: **35**. Ser. *Striatisporae*, *C*. *theleboloides* (type of *P*. *vinacea*,S); **36**. Ser. *Tenuistriatae*, *C*. *oligotricha* (holotype,H); **37-39**. Sect. *Villosae*: **37-38**. Ser. *Villosae*: **37**. *C*. *villosa* (holotype,LPS); **38**. *C*. *gemella* (holotype,H); **39**. Ser. *Obtusipilosae*, *C*. *magnifica* (isotype,HMAS); **40**. Sect. *Micropilosae*, *C*. *stercoraria* (holotype,PRM).



Figs.41-47. SEM of ascospores of *Cheilymenia*: 41. Sect. *Paracheilymeniae*, *C. aurantiacorubra* (isotype,BRA); 42. Sect. *Raripilosae*, *C. raripila* (isotype of *C. notabilispora*,J.Mor.); 43-44. Sect. *Cheilymenia* ser. *Cheilymenia*: 43. *C. stercorea* (Branžež,20.III.1967,J.Mor); 44. *C. asteropila* (isotype,J.Mor.); 45-47. Sect. *Pseudoscutelliniae*: 45-46. Ser. *Coprinariae*, *C. magnipila* (isotype,J.Mor.); 47. Ser. *Fuscae*, *C. cadaverina* (holotype,PRM).

GENERIC AND INFRAGENERIC DIAGNOSES

Genus **Cheilymenia** Boud. emend. J.Moravec **emend nov.**
= Cheilymenia Boudier, Bull. Soc. Myc. Fr. 1: 105, 1885 - pro parte.
= Peziza Dill. ex L. ser. Lachnea (Retz.) Fries, Syst. Myc. 2:77,1823 - p.p.
= Peziza Dill. ex L. ser. Lachnea (Retz.) Fr. subgen Scutellinia Cooke, Mycograph. 1:260, 1879 - p.p.
= Lachnea Gillet, Champ. Fr. Discom.p. 57, 1879 - p.p.
= Lachnea Gill. subgen. Scutellinia (Cooke) Phillips, Man. Brit. Discom. 217, 1887 - p.p.
= Lachnea Gill. subgen. Lachneolina Svr. sectio Tenues Svr. subsectio Fuscae Svrček, Acta Mus. Nat. Pragae, p. 34, 1948
= Lachnea Gill. subgen. Lachneolina Svr. sectio Setosae Svr. subsectio Luteae Svrček, Acta Mus. Nat. Pragae p. 42, 1948.
= Patella Weber in Wiggers, Prim. Fl. Hols. 106, 1780 - p.p.
= Humaria Fuckel, Jahrb. Nass. Ver. Nat. 23-24:320, 1870.
= Humariella Schroeter, Pilze Schles. 2:36, 1908 - p.p.
= Coprobia Boudier, bull. Soc. Myc. Fr. 1:107, 1885 - p.p.

Apothecia paragymnohymenialia, minuta vel mediocria, sessilia, orbicularia vel depressa, primum subglobosa, turbinata vel convexa, dein leniter patellaria, discoidea usque pulvinata, carnosa, hymenio rare etiam albido-subochraceo, luteo, luteo-ochraceo, ochraceo, luteo-aurantiaco, aurantiaco, aurantiaco-rubro rubro usque coccineo, aureo-cinnamomeo, etiam rare fusco; pars externa apothecii minute vel crasse granulata, subglabra, parte basali hyphis sparsis, superficialibus obsita, subhirsuta vel setis obsita. **Pili** diversiformes: hyphoidei, flexuosi, tenuiter tunicati, septati, superficiales e cellulis ecrescentes, hyalini vel etiam pili recti, superficiales, obtusi vel acuminati, crasse tunicati, septati, subhyalini vel luteoli, basi simplices vel obtuse bifurcati, sed etiam pili magni, recti vel curvati, rigidi, crasse tunicati, septati, basi obtuse subradicati vel radicati, simplices,vel bifurcati, multituberosi usque multifurcati, sursum acuti vel obtusi, luteo-fusci vel fusci, supra nonnumquam decolorati; etiam pili stellati (asteropili) adsunt. **Excipulum** externum e textura globuloso-angulari, excipulum internum (medulla) e textura globuloso-angulari sed hyphis sparsis parte inferiore mixta,vel textura subintricata usque intricata constat. **Asci** cylindracei, operculati, octospori, non amyloidei. **Paraphyses** filiformes, rectae, apice sensim vel valde incrassatae vel clavatae usque capitatae et lobato-furcatae , pigmento luteo vel luteo-aurantiaco usque aurantiaco, carotenoideo instructae. **Ascosporae** monostichae vel distichae, ellipsoideae vel rare subglobosae, eguttulatae, subhyalinae vel subluteolae, (in CB + acidum lacticum pigmento luteo, lucem frangente impletae), perisporio separabili, sublaevi vel saepe verrucis cyanophilis, rotundatis vel elongatis, irregularibus, usque reticulum incomplete formantes, interdum perisporio longitudinaliter striato, costis cyanophilis, anastomosantibus, vel perisporio dense irregulariter subreticulato.
Habitat: Ad excrementa vaccina, equina, cervina, capreolina, cuniculina, leporina, murina, canis humana, lemurina, anatina, anserina, Ovibos moschata etc., in stercore et ad terram stercoratam, ad sedimentis stercoratis, etiam ad folia graminea deiecta accumulata in hortis, fructibus putridis, stramine putrido, in paleis putrescentibus, rarius ad alga putrida, ad pilos cadaveris marcidi cuniculi, sed etiam ad terram humidam nudam vel inter muscos et plantis saepe in Urticetis; locis immundis, in pascuis, arvis, hortis, pratis, in vicinitate pagorum vel in silvis.
Species typica: **Peziza stercorea** Fries, Syst.Mycol.2:87,1822 sensu auctorum presentorium. = **Cheilymenia stercorea** (Fr.) Boudier, Hist.Class.Discom.Eur. p.63, 1907. (Non Patella stercorea Weber in Wiggers, Prim.Fl.hols.106,1780- nomen superfluum pro synonymo Elvela lentiformis Scopoli, Fl.carn. 2:481,

ed.2, 1772, nomen dubium).
= Cheilymenia ciliata (Bull.) Maas Geesteranus, Koninkl.Nederl.Akad. v. Wetenschappen-Amsterdam, ser.C.72,N°3:313, 1969.
= Peziza ciliata Bulliard, Herb.Fr. 438,fig.2, 1789 - nomen nudum; :Bulliard, Hist.Champ.Fr.(2):257, 1791 - nomen praeoccupatum.
(Non Peziza ciliata Hoffmann, Veg. crypt. 2:25, 1790).

Sectio 1. **Coprobiae** (Boud.) J.Moravec, **comb. et stat. nov.**

Basionym: Coprobia Boudier, Bull. Soc. Mycol. Fr. 1:107, 1885.

Apothecia sessilia, orbicularia, subglobosa evl convexa, dein discoidea usque pulvinata; thecio laeve vel granulato, ochraceo, sordide subochraceo, aurantiaco, luteo-aurantiaco vel aurantiaco-coccineo; apothecia extus subglabra, hyphis sparsis, hyalinis, septatis, flexuosis,brevibus obsita; Excipulum textura globuloso-angulari, excipulo interno(medulla) e textura globuloso-angulari sed cum hyphis et cellulis elongatis, inflatis, sparsis mixta. Ascosporae perisporio longitudinaliter striato instructae.
Species typica: Peziza granulata Bulliard, herb. Fr. t. 438, fig.3, 1790; Hist. Champ. Fr. 258, 1791,: Fries, Syst. Mycol. 2:67, 1822.
= **Cheilymenia granulata** (Bull.) J.Moravec **comb. nov.**
Basionym: Peziza granulata Bulliard, Herb. Fr. t. 438, fig. 3, 1790; : Fries, Syst. mycol. 2:67, 1822; = Coprobia granulata (Bull.) Boudier, Hist. Class. Discom. Eur. 69, 1907. Species ceterae:
Cheilymenia striata (Thind, Cash et Singh) J.Moravec **comb. nov.**
Basionym: Ascophanus striatus Thind, Cash et Singh, Mycologia 51:460,1959.
Cheilymenia sordida (J.Mor.) J.Moravec **comb. nov.**
Basionym: Coprobia sordida J.Moravec, Čes. Mycol. 38: 154, 1984.
Cheilymenia crassistriata (J.Mor.) J.Moravec **comb. nov.**
Basionym: Coprobia crassistriata J.Moravec, Mycotaxon 28:501,1987.
Cheilymenia karstenii nom. nov. Basionymum: **Ascophanus flavus** Karsten,medd. Soc.Fauna Fl.fenn.16:105,1889.= Coprobia flava (Karst.)Thind et Kaushal, Kavaka 6:26,1978.(Non Humaria flava Fuckel,J.B.Nass.Ver.Nat.23-24:322,1870= Cheilymenia flava (Fuck) Boud.Hist.Class.Disc.Eur.63,1907 g.e.Tricharina flava (Fuck.) J.Mor.).

Sectio 2 **Striatisporae** sect. nov.

Apothecia lutea, vitellina usque aurantiaca, extus pilis obsita; pili superficiales, basi tuberosi, simplices vel obtuse subradicantes, etiam pili basi subradicantes vel radicantes, multituberosi usque multifurcati. Ascosporae perisporio longitudinaliter striato instructae. Medulla e textura globuloso-angulari cum hyphis inflatis sparsis mixta, subintricata usque intricata. Paraphyses filiformes,apices non vel leniter incrassatae.
Species typica: Peziza theleboloides Albertini et Schweinitz, Consp. fung. 321, 1805; :Fries, Syst. mycol. 2:88, 1822.
= Cheilymenia theleboloides (Alb. et Schw.) Boudier, Hist. Class. discom. d'Eur. 62, 1907.

Series a. **Striatisporae ser. nov.**

Ascosporae perisporio costis crassis vel mediocriis, anastomosantibus vel costis atque cum tuberculis cyanophilis. Pili superficiales, basi tuberosi vel bulboso-bifurcati, hyalini, subhyalini usque luteoli, flexuosi vel recti, apice obtusi vel acuminati; tunica 0.5-2.5 μm crassa. Excipulum internum (medulla) textura globuloso-angulari cum hyphis sparsis, inflatis mixta usque textura subintricata.
Species typica: Peziza theleboloides Albertini et Schweinitz, Consp.fung. 321, 1805; ex Fries, Syst. mycol. 2: 88, 1822.
= **Cheilymenia theleboloides** (Alb. et Schw.) Boudier (1907).
Species ceterae: **Cheilymenia lemuriensis** Heim in Le Gal, Prodr.Fl.Mycol. Madag.4:417,1953.

Series b. Tenuistriatae ser. nov.

Ascosporae perisporio striis tenuibus donatae. Pili longi, magni, basi subradicantes vel radicantes et obtuse bifurcati vel multifurcati, multituberosi vel multiradicati. Medulla textura subintricata usque intricata.
Species typica: Peziza oligotricha Karsten, Not. Sällsk. Fauna Fl. Fenn. Föhr. 10:127, 1869.
= Cheilymenia oligotricha (Karst.) J.Moravec comb. nov.
Basionym: Peziza oligotricha Karsten, Not. Sällsk. Fauna Fl. Fenn. Föhr. 10:127, 1869.
(=Peziza vitellina Persoon, Myc. Europ. 257, 1822; : Fries, Syst. mycol. 2:84, 1822 - nomen dubium).
Species ceterae:
Cheilymenia citrinella (Velen.) Svrček, Čes. Mykol. 31:69, 1977.
Cheilymenia pediseta (Clements) J.Moravec comb. nov.
Basionym: Sepultaria pediseta Clements, Bot. Surv. Nebr. 4:13, 1896

Sectio 3. Villosae sect. nov.

Apothecia lutea usque aurantiaca, extus pilis tenuis copiose vestita. Pili superficiales usque subradicantes, basi bulbosi, obtuse bifurcati vel attenuati et simplices, tenui, flexuosi usque recti, apice obtusi vel subacuminati usque acuti, longi, subhyalini usque subfusci. Medulla e textura intricata constat. Ascosporae sublaeves vel laeves.
Species typica :
Cheilymenia villosa Gamundí, Bull. Soc. Argent. Bot. 14: 173, (1972).

Series a. Villosae ser. nov.

Apothecia pilis longis,apice obtusis usque acutis copiose vestita.
Species typica:Cheilymenia villosa Gamundí, Bull.Soc.Argent.Bot.14:173, 1972.
Species ceterae: Cheilymenia gemella (Karst.)J.Moravec,Mycotaxon 37:469,1990.

Series b. Obtusipilosae ser. nov.

Apothecia pilis brevis usque longis, apice obtusis obsita.
Species typica: Coprobia magnifica W.-y.Zhuang et Korf, Mycotaxon 35:298, 1989. = Cheilymenia magnifica (W.-y.Zhuang et Korf) J.Moravec comb. nov.
Basionym: Coprobia magnifica W.-y.Zhuang et Korf, Mycotaxon 35:298,1989.

Sectio 4. Micropilosae sect. nov.

Apothecia igneo-coccinea, extuss subnuda, marginemque obscure punctata. Medulla e textura intricata constat. Pili rarisimi, ad 100 μm longi, subhyalini vel subfusci, basi simplices; etiam cellulis elongatis, crasse tunicatis, fuscis. Ascosporae subgloboso-ellipsoideae, perisporio verrucis cyanophilis, minutis donatae.

Species typica (et unica): Humaria stercoraria Velenovský, Mon. Discom. Boh. Pragae, 1:330, 2:Taf. 24, fig.22, 1934.
= Cheilymenia stercoraria (Velen.) J.Moravec comb. nov. Basionym: Humaria stercoraria Velenovský, Mon.Discom.Boh.Pragae 1:330,1934.

Sectio 5. Paracheilymeniae sect. nov.

Apothecia minuta (0.5-2 mm diam.), turbinata vel columnaria, luteo-aurantiaca, extus pilis brevibus, superficialibus, basi simplices, apice subacutis vel acutis. Excipulum externum textura angulari usque globulosa, medulla e cellulis subglobosis, hyphis irregularibus parvis mixta. Ascosporae perisporio dense irregulariter subreticulato. **Species typica:** Ascobolus pulcherrimus Crouan et Crouan,Ann.Sci.Nat.(Bot.)IV,10:196,1858.

= Cheilymenia pulcherrima (Crouan et Crouan) Boudier, Hist. Class. Disc. Eur. 63, 1907. Species ceterae:
Cheilymenia aurantiacorubra Thind et Kaushal, Indian Phytopath.33:428, 1980.

Sectio 6. Insigniae sect. nov.

Apothecia minuta (0.6-1 mm diam.), doliiformia, luteo-aurantiaca, extus pilis rigidis, crasse tunicatis, septatis, apice acutis, basi bulboso-furcatis, haud radicatis. Excipulum externum et medullare textura globuloso-angulari, pars externa e cellulis crasse tunicatis. Ascosporae magni, perisporio laevi.
Species typica (et unica): Ascobolus insignis Crouan et Crouan, Ann. Sci. Nat. (Bot.) IV 10:196, pl.13 H f, 38-43, 1858.
= Cheilymenia insignis (Crouan et Crouan) Boudier,Hist.Class.Disc.Eur.63, 1907.

Sectio 7. Raripilosae sect. nov.

Apothecia convexa, minuta (0.6-2 mm diam.), luteo-aurantiaca, extus hyphis vel pilis brevibus, sparsis, subhyalinis, flexuosis vel rectis, septatis sed etiam non septatis obsita. Excipulum externum et medullare e textura globuloso-angulari. Ascosporae perisporio dense irregulariter incomplete reticulato, costis valde cyanophilis.
Species typica: Peziza raripila Phillips, Grevillea 7:23, 1878.
= Cheilymenia raripila (Phill.) Dennis, Kew Bull. 14:428,(1960).
Species ceterae:
Cheilymenia coprogena (Berk. et Br.) Rifai, Vehr. Konninkl. Neder. Akad. Wetensch. Nat. 57:136, 1968.
Cheilymenia bohemica (Velen.) J.Moravec comb. nov.
Basionym: Fimaria bohemica Velenovský, Mon. Discom. Boh. Pragae 1: 332, 2: taf. 24, fig. 16, 1934.

Sectio 8. Cheilymenia sect. typica

Apothecia lutea, vitellina, luteo-aurantiaca vel rubro-aurantiaca sed etiam pallide subochracea, extus pilis et setis longis obsita.
Pili marginales longi, rigidi, crasse tunicati, apice acuminati, basi radicati vel multiradicati usque coralliformi, sed etiam obtuse radicati, partim etiam pili suprficiales vel stellati (asteropili). Ascosporae sublaeves, tunica externa (perisporium) cum maculis et striis secundariis vel minute verruculosa. Medulla e textura subintricata usque intricata.
Species typica: Peziza stercorea Fries, Syst. Mycol. 2:87, 1822, sensu auctorum presentorium.
= Cheilymenia stercorea (Fr.) Boudier, Hist. Class. Discom. Eur. 63, 1907, sensu auctorum presentorium.

Series a. Cheilymenia

Pars externa apotheciorum pilis stellatis (asteropilis obsita. Limbus marginalis e cellulis parvis, prismaticis in seriebus verticalibus ordinatis, clavatio-terminatis instructus.
Species typica: Peziza stercorea Fries, Syst. Mycol. 2:87, 1822.
= Cheilymenia stercorea (Fr.) Boudier, Hist. Class. Discom. Eur.63, 1907.
Species ceterae:
Cheilymenia asteropila J.Moravec, Mycotaxon, 37:463,(1990).

Series b. Pallidae ser. nov.

Apothecia turbinata, pilis marginalibus longis, basi radicantibus, multifurcatis obsita. Pars externa ad basim apotheciorum pilis hyphoideis obsita. Hymenio pallide subochraceo.
Species typica (et unica):
Cheilymenia pallida Bell et Dennis, Trans. Br. Mycol. Soc. 57:180. 1971.

Sectio 9. Pseudoscutelliniae sect. nov.

Apothecia aurantiaca vel aurantiaco-rubra usque rubra, sed etiam fusca vel aureo-cinnamomea, extus pilis rectis vel curvatis, rigidis, radicantibus, basi simplicibus sed attenuato-truncatis vel bifurcatis usque quadrifurcatis, luteo fuscis usque fuscis, etiam supra decoloratis, septatis, crasse tunicatis, apice subacutis vel acutis, longis, genere Scutellinia similibus. Excipulum internum (medulla) e textura intricata constat. Ascosporae perisporio verrucoso, pustulato vel cristulato-subreticulato, verrucis cyanophilis, sed etiam perisporio sublaevi.
Species typica: Lachnea rubra Cooke ex Phillips, British Discom. 225, 1887. = Cheilymenia rubra (Cooke ex Phill.) Boudier, Hist. Class. Disc. Eur. 63, 1907.

Series a. Pseudoscutelliniae ser. nov.
Apothecia rubra vel aurantiaco-rubra, rare etiam laete aurantiaca.
Pili breviores (usque 600 µm).
Species typica: Lachnea rubra Cooke ex Phillips, British Discom. 225,1887.
= Cheilymenia rubra (Cooke ex Phill.) Boudier,Hist.Class.Disc.Eur.63,1907.
Species ceterae:
Cheilymenia humarioides (Rehm) Gamundí, Bull. Soc. Argent. 14:168, 1972.
Cheilymenia pseudohumarioides Diss. J.Mor.et Sivert. in J.Moravec, Mycotaxon 36:173,1989.
Cheilymenia fimicola (de Not. et Bagl.) Dennis, Brit. Ascom.,ed.2:45,1978.
Cheilymenia liskae J.Mor., Fell.et Landa in J.Moravec, Mycotaxon 36:177, 1989.
Cheilymenia fraudans (Karst.) Boudier, Hist. Class. Disc. Eur. 63, 1907.

Series b. Coprinariae ser. nov.
Apothecia luteo-aurantiaca vel aureo-cinnamomea usque aurantiaca.
Pili longi, magni (usque 1200 x 55 µm).
Species typica: Peziza coprinaria Cooke, Grevillea 4:91, 1875.
=Cheilymenia coprinaria (Cooke) Boudier,Hist.Class.Disc.Eur.63, 1907.
Species ceterae:
Cheilymenia magnipila J.Moravec, Čes. Mykol. 22:35, 1968.
Cheilymenia megaspora (Gamundí) J.Moravec, Mycotaxon 35:66, 1989.

Series b. Fuscae (Svr.) comb. et stat. nov.
Basionym: Lachnea Gill. subsectio Fuscae Svrček, Acta Mus. Nat. Pragae, 4. B. N°6 p.34,1948.
Apothecia ochraceo-fusca, fusca, nitida, pili latiori, brevi.
Species typica (et unica): Lachnea cadaverina Velenovský, Mon. Disc. Boh. Pragae, 1:412, 1934.
= **Cheilymenia cadaverina** (Velen.) Svrček, Česká Mykol. 31:69,1977.

REMARKS ON THE GENERIC AND INFRAGENERIC CLASSIFICATION AND INDIVIDUAL SECTIONS AND SERIES

In accordance with the reasons presented in the introduction to this paper, the infrageneric classification of the genus Cheilymenia presented many difficulties. Many features important for generic delimitation are variable. Various types of hairs with intermediate forms are a most remarkable feature of the genus. The shape of hairs with various character combinations e.g. ascospore ornamentation, anatomy of apothecia and colour of hymenium does not provide a reliable basis for subgeneric or even generic delimitation. To maintain a single large genus is, therefore, quite natural.

The genus Cheilymenia Boud. em. J.Mor. is a natural member of the family Pyronemataceae Corda em. Korf, subfamily Scutellinioideae Clem. em. Korf, tribe Scutellinieae (Clem.) Pant et Tewari em. Korf. It differs from the closely related genus Scutellinia (Cooke) Lamb. in having eguttulate ascospores, a yellow refractive colour in mature ascospores when stained in Cotton blue in lactic acid, and an easily separable outermost ascospore wall (perisporium). The separable perisporium is, however, also a feature of several species of Scutellinia referred to the sections Minutae Svr. and Pseudocheilymeniae Svr., which, however, lack the yellow refractive colour in mature ascospores. In addition, the majority of species of Cheilymenia have a coprophilous habitat.

Section 1. Coprobiae represents a rather homogenous group of species, which are characterized by apothecia in which the external surface bears no hairs but is covered, especially near the base of apothecia, with scarce, hyaline, septate hyphae with thin to slightly thickened walls. In addition, the apothecia have a simple anatomy and the excipulum is composed throughout of textura globulosa-angularis, with only occasional hyphal elements in the medullary excipulum. The ascospores have longitudinal striation on the perisporium. There is, however, no basic difference reliable for generic or subgeneric delimitation between the species of Coprobia and species of Cheilymenia. The absence of acuminate hairs may also be seen in apothecia of several species of typical Cheilymenia.

Section 2. **Striatisporae** with two series, a. Striatisporae and b. Tenuistriatae, includes two seemingly heterogenous groups. However, after examination and comparison of all features of all taxa, it is evident that all taxa are related to each other. The shape and colour of the apothecia are very similar in both series. The excipulum is only slightly differentiated in the species of ser. Striatisporae, with only occasional but distinct, inflated hyphae (a textura subintricata) in the medullary layer. Similar hyphae, having in both series strongly cyanophilic septa, are more commonly present in the medullary layer of ser. Tenuistriatae, forming a textura subintricata to intricata. The ectal excipulum, a textura globulosa-angularis, is composed in both series of very similar cells, especially in the marginal part. The hairs are, on first sight, quite different in the second series. However, examination of many collections shows that this difference is not a reliable distinguishing feature. The hairs are superficial to pseudorooting, with simple or bifurcate, bulbous to obtusely rooting base with "germs of roots" in ser. Striatisporae, whilst the base is bulbous, obtusely bifurcate to multituberous, grading to obtusely rooting, multifurcate, widely rooting base in the ser. Tenuistriatae. Intermediate forms of hairs are present in both series. C. citrinella may be considered a transitional form between the two series with regard to the type of hairs it possesses. The ascospores of both series bear a longitudinally striated perisporium though the striation is much finer in ser. Tenuistriatae. The paraphyses of both series are with only a slightly or not enlarged apex.

Section 3. **Villosae** is represented by two series showing both superficial marginal and rooting marginal or receptacular hairs. The latter are flexuous, narrow, villose, copious, and may have a rooting, simple, attenuate or bifurcate, but also bulbous base. The species of series b. *Obtusipilosae* is distinguished by rounded tops of hairs. The excipulum is differentiated, the medullary layer comprising a textura intricata: The ascospore perisporium is nearly smooth or with fine irregularly elongated warts.

Section 4. ***Micropilosae*** is a peculiar monotypic section. The apothecia of the type species, *C. stercoraria* may be hairless or with only hyaline hyphae, but obtuse, yellow-brown, extremely short hairs or germs of hairs (brownish cells with thickened walls) occur. Such hairs are very rare and may be missing on the whole external surface of the apothecia. The combination of the type of hairs with a textura intricata in the medullary layer of the excipulum, subglobose ascospores bearing a minutely warted perisporium, and the scarlet hymenium of the apothecia is unique.

Section 5. ***Paracheilymeniae*** is represented by two species with turbinate to columniform apothecia of a simple anatomy and having short, superficial receptacular hairs, which are not distinguished from the marginal hairs, and ascospores with a smooth perisporium. The two species of the section differ in ascospore size only.

Section 6. ***Insigniae*** is represented by only one species with apothecia having a simple anatomy but bearing reddish-brown, comparatively long hairs with bulbous obtusely multifurcate base, and very large, smooth ascospores. I was unable to examine the authentic material of this taxon from the herbarium of the Crouan brothers deposited in CONC. For an illustration of apothecia, hairs and ascospores, see Brummelen (1986).

Section 7. ***Raripilosae*** includes three species characterized by very small, obconical, "Lasioboloid" apothecia with a simple anatomy, externally covered by short, inconspicuous subhyaline superficial hairs with a simple base. The hairs are absent or reduced to hyphoid hairs in the third species. Further remarkable features are the large ascospores and an ascospore perisporium covered with fine to conspicuous, strongly cyanophilic crests forming an irregular and incomplete reticulum.

Section 8. ***Cheilymenia***, the typical section of the genus, is represented by the nomenclatural type species, *C. stercorea* and includes 3 species characterized by long, marginal, rigid setae, which may be septate or not (both septate or aseptate hairs occur in the type species) with a wide, multifurcate to coralloid rooting base with wide roots and many small coralloid roots. This remarkable shape of the base is combined with the presence of stellate hairs (asteropili) in both species of ser. a. *Cheilymenia*.The type species of the second ser., b. *Pallidae*, has the same type of marginal hairs, but the stellate hairs are absent. (I have found only few irregularly angular to stellate cells in one collection from New Zealand). The apothecia of this second series are without a conspicuous marginal collar. The marginal collar, comprising smaller, prismatic, vertically arranged cells, is a remarkable feature of ser. a. *Cheilymenia*. The medullary excipulum is composed of a textura subintricata grading into a nearly typical textura intricata. The ascospore perisporium is smooth, with only occasional spots and secondary wrinkling, or it bears fine, densely arranged warts. The type species of the second ser., b. Pallidae, C. pallida, has extremely small ascospores.

Section 9. Pseudoscutelliniae is a rather homogenous group of species which are similar to those of the genus Scutellinia. They have a well-differentiated excipulum with the medullary layer comprising a textura intricata, rooting thick-walled hairs with a simply attenuate, often curved or bifurcate to multifurcate typically rooting base. The species of ser. a. Pseudoscutelliniae resemble species of the section Minutae Svr. and Pseudocheilymeniae Svr. of the genus Scutellinia, especially in the type of hairs, anatomy and colour of apothecia and ascospore ornamentation. However, all species of the section Pseudoscutelliniae as well as all species of the genus Cheilymenia possess ascospores which exhibit a yellow refractive colour when stained with CB in lactic acid. The second series b. Coprinariae includes species whose apothecia lack the red pigment of the first typical group (C. coprinaria sensu J.Moravec (1968) is partly C. rubra). The hairs of the second series are long, broad, and extremely thick-walled, with a typically rooting base. The third series c. Fuscae is represented by one species characterized by small brownish apothecia (which may have an ochraceous colour when young). The unusual colour of the apothecia is combined with very wide, comparatively short, rooting hairs with mostly simple attenuate bases, and with broadly ellipsoid to subglobose ascospores bearing a minutely warted perisporium.

The proposed new emendation and infrageneric arrangement of the genus Cheilymenia is a result of detailed examination of relevant type material and a great number of other collections. The list of accepted species may be modified and supplemented by several new species and probably by other species of which the type material has not yet been examined.

IMPERFECTLY KNOWN AND EXCLUDED TAXA, AND IMPORTANT SYNONYMS

Cheilymenia alleghenensis Denison, Mycologia 56:732, 1964. (OSU-isotype)
= **Scutellinia alleghenensis** (Denison) J.Moravec, Mycotaxon 36:180, 1989.

Cheilymenia alpina (Fuck.) Boudier, Hist.Class.Discom.Eur., 1907.
= Humaria alpina Fuckel, J.B. nass. Ver.Naturk. 29-30:32, 1875.
(= Humaria stercorea var. aurantiaco-flava Fuckel, Jb.nassau.Ver.Naturk. 27-28:64, 1873.
= **Cheilymenia stercorea** (Fr.) Boud.

Humaria anceps Rehm, Discom. p.1269, 1896. (Two packets in S labelled as type. One of them is **Cheilymenia theleboloides** (Alb. et Schw.) Boud. , the second packet contains apothecia of **Cheilymenia granulata** (Bull.) J.Mor.

Cheilymenia ascoboloides (Bert.:Mont.) Boudier in Ramsbottom, Trans.Br. mycol.Soc. 4:367, 1914. = Peziza ascoboloides Bert.:Montagne, Ann. Sci. Nat. (Bot.) II, 8:363, 1837. (K- holotype).
= **Cheilymenia theleboloides** (Alb.et Schw.) Boud.

Cheilymenia aurea Boudier, Hist.Class.Discom.Eur. 63, 1907.(PC-holotype). Note: the curators of the PC herbarium were unable to find any apothecia on substrate of this type collection, and I also had no succes in finding them. It is impossible to recognize this taxon exactly. According to the

481 4 for *Arhenia* read *Arrhenia*

description and illustration in Boudier (1909-1910) it is a species close to **Cheilymenia fimicola** (de Not.et Bagl.) Dennis. *C. fimicola* differs from *Cheilymenia coprinaria* (Cooke) Boud. by much larger ascospores and shorter hairs. The ascospores of the holotype (UPS) and syntype (S) of *Arhenia fimicola* de Notaris et Baglieto, Hedwigia 5:108, 1866, measure 17-21 x 10.5-13.5 µm,and hairs up to 400 x 30 µm. I have examined also several collections of *C. fimicola* mostly from Scandinavia.

Cheilymenia bisetosa (Thind et Kaushal) Yang et Korf, Mycotaxon 24: 520, 1985 = *Tricharina bisetosa* Thind et Kaushal, Indian J. Mycol. Plant. Pathol. 9:229, 1979. (PAN 2408-holotype, BRA and J.Mor.-isotypes).
= **Paratrichophaea** sp.? cf. *Paratrichophaea albescens* (Diss. et Raitv.) T. Schumacher, mycotaxon 33:150, 1988 (see also T. Schumacher (1989)).

Coprobia bohemica (Velen.) Svrček, Čes. mykol. 31:69, 1977. = *Fimaria bohemica* Velenovský, Mon. Discom. Boh. Pragae 1:332, 2: taf. 24, fig. 16, 1934. (PRM 149767-holotype).
= **Cheilymenia bohemica** (Velen.) J.Mor.

Cheilymenia calvescens Boudier, Icones, Livraison II. (December 1906), pl. 385, 1906.
= **Scutellinia crucipila** (Cooke et Phill. in Cooke) J.Moravec, Čes. Mykol. 38:149, 1984.

Cheilymenia ciliata (Bull.) Maas Geesteranus, Koninkl. Neder. Akad. v. Wetenschappen-Amsterdam, ser. C, 72, N°3, p. 313, 1969. = *Peziza ciliata* Bulliard, Herb. France pl.448, fig. 2, 1791- nomen praeoccupatum.
Notes: *Peziza ciliata* Bulliard was described in 1891, the date 1789 mentioned by Maas Geesteranus (1969) is incorrect for the validly published taxon . *Peziza ciliata* Bull. is a later homonym of *Peziza ciliata* Hoffman, Veg. Cryptog. 2:25, 1790.
= **Cheilymenia stercorea** (Fr.) Boud.

Cheilymenia crucipila (Cooke et Phill.in Cooke) Le Gal, Discom.Madag. 111, 1953. = *Peziza crucipila* Cooke et Phillips in Cooke, Mycograph. p.136,1876.
= **Scutellinia crucipila** (Cooke ex Phill. in Cooke) J.Mor.

Cheilymenia dalmeniensis (Cooke) Boudier, Hist.Class Discom.Eur.63, 1907.
= *Peziza dalmeniensis* Cooke, Grevillea 3:66, 1874. (K-holotype).
= *Cheilymenia oligotricha* (Karst.) J.Mor.

Peziza eclecta Berk. et Cooke in Cooke, Grevillea 5:60, 1876. (K-holotype).
= **Cheilymenia theleboloides** (Alb. et Schw.) J.Mor.

Cheilymenia flava (Fuck.) Boudier, Hist.Class.Discom.Eur.63, 1907.
= *Humaria flava* Fuckel, J.B. Nassau.Ver.Naturk.23-24:322,1870. (G-holotype).
= **Tricharina flava** (Fuck.) J.Moravec **comb. nov.** Basionym: *Humaria flava* Fuckel, J.B. Nassau.Ver.Naturk. 23-24:320, 1870.
Note: it is a *Tricharina* species with subglobose to cup-shaped apothecia externally covered by dense villose hairs. The ascospores are larger than these of all species treated in Yang et Korf (1985).

Cheilymenia glumarum (Desm.) Svrček, Čes.Mykol. 28:130, 1974. = *Peziza glumarum* Desmazieres, Ann.Sci.Nat.15:129, 1841. (G-holotype, K-syntype)
= **Cheilymenia theleboloides** (Alb.et Schw.) Boud.

Humaria granulata Bull.) Quél. var. *robusta* Starbäck, Bot.Notiser 1898: 211, 1898. (S-holotype).
= **Cheilymenia granulata** (Bull.) J.Mor.

Humaria hirtella Rehm f. *minor* Rehm, Ascomyceten exs. 605, 776
= *Lachnea amphidoxa* Rehm, Discom. p. 1048, 1896. (S- syntypes).
= **Cheilymenia rubra** (Cooke ex Phill.) Boud. Notes: the 4 packets labelled "*Humaria hirtella* Rehm f. *minor*" deposited in S herbarium (collections

Winter, April 1881, Zürich, and Sydow, July 1895, Berlin) have been determined by me as *C. rubra*. Another isosyntype (NY), Winter, Zürich, April 1881 (in J.Moravec 1989 erroneously written "1888"), has also been examined (see J.Moravec 1889). Other two packets from S labelled *H. hirtella* f. *minor* represent a *Tricharina* species, probably *Tricharina ochroleuca* (Bres.) Eckblad. It may explain why *L. amphidoxa* was adopted as *Tricharina* sp. by several authors. However, the two original collections (S- 4 packets and NY one packet) represent *C. rubra*.

Coprobia humana (Velen.) Svrček, Čes. mykol. 31:69, 1977. = *Fimaria humana* Velenovský, Mon.Discom.Boh.Pragae 1:331,2:taf.24,1934.(PRM 150839-holotype). =***Cheilymenia theleboloides*** (Alb.et Schw.) Boud.

Cheilymenia hyalochaeta (Speg.) Gamundí, Lilloa 30: 326, 1960.= *Peziza hyalochaeta* Spegazzini,Ann.Soc.Cient.Arg.10:24,1880. (LPS 27338-holotype). = ***Cheilymenia raripila*** (Phill.)Dennis

Cheilymenia hyphopila J.Moravec, Čes.Mykol. 38:150, 1984. (PRM-holotype, BRA and J.Mor.-isotypes).
= ***Cheilymenia theleboloides*** (Alb.et Schw.) Boud.

Cheilymenia lentiformis (Pers.ex Sacc.) Boudier, Hist.Class.Discom.Eur. 63, 1907. (K-neotype selected by T.Schumacher 1989). Notes: Six apothecia on soil are small (0.5 mm when dried), externally covered by dark hairs. Although Boudier (1907) and T.Schumacher (1989) considered this taxon a member of *Cheilymenia*, I cannot confirm this opinion: the ascospores seen by me were immature and without a yellow refractive colour when stained with CB. The combination of the small apothecia with the terrestrial habitat separates this taxon from all species of *Cheilymenia* I have seen.

Coprobia magnifica W.-y.Zhuang et Korf, Mycotaxon 35:298, 1989. (HMAS 57687-isotype).
= ***Cheilymenia magnifica*** (W.-y.Zhuang et Korf) J.Mor. Notes: This is a member pf the genus *Cheilymenia* section *Villosae*, series *Obtusipilosae*. It differs from all species of the section *Coprobiae* by its pale brownish thick-walled hairs, which are long and villose and mixed with thin-walled hyphae. The ascospores are nearly smooth or with a very fine irregular warts on the perisporium. The "horizontal striation" of the perisporium mentioned by Zhuang et Korf (1989) was caused by heating the slides and has not been seen when the slides were stained with CB which stains promptly without heating.

Cheilymenia micropila Svrček et J,Moravec in J.Moravec, Čes.Mykol. 22:37, 1968. (PRM-holotype, BRA and J.Mor.-isotypes).
= ***Cheilymenia stercoraria*** (Velen.) J.Mor. Note: Only the holotype of *C. micropila* is identical with the holotype of *Humaria stercoraria* Velen.

Cheilymenia notabilispora J.Moravec, Čes.Mykol. 22: 36,1968. (PRM 628981-holotype, BRA and J.Mor.-isotypes).
= ***Cheilymenia raripila*** (Phill.) Dennis.

Coprobia pileiformis Svrček, Čes.Mykol.32:11,1978.(PRM 805292-holotype).
= ***Galeoscypha pileiformis*** (Svr.) Svrček et J.Moravec,Čes.Mykol.43:210,1989.

Peziza scubalonta Cooke et Ger.in Cooke,Grevillea 4:92,1875. (K-holotype).
= ***Cheilymenia stercorea*** (Fr.) Boud.

Cheilymenia stercorea (Web.in Wigg.)Boudier, Hist.Class.Discom.Eur.62,1907.
= *Patella stercorea* Web. in Wiggers Prim.Fl.hols.106,1780
= ***Cheilymenia stercorea*** (Fr.) Boud. Notes: *Patella stercorea* Weber in Wiggers is a superfluous name for *Elvela lentiformis* Scop. or *Elvela lutea* Scopoli, Fl.Carn.2:481,1772. None of these taxa represents what we today call *C. stercorea* (see Maas Geesteranus (1969)). Another used name, *Peziza ciliata* Bull. is invalid (see above). Therefore,

we propose just to cite Fries as the author of *P. stercorea* and to use this sanctioned name validated by Fries, and thus preserve the epithet which has been applied to a stellate-setose species and in use for so many years. It is, however, necessary to select a lectotype (the lectotype selected by Denison (1964) is in a very poor condition).Another possibility is that the Buliard's figure of *C. ciliata* may serve as an acceptable lectotype for *P. stercorea* Fr.

Peziza stercorea Pers. var. *gemella* Karsten, Not.Sällsk.Faun.Fl. Fenn. Föhr.10:126,1868. (H-holotype).
= ***Cheilymenia gemella*** (Karst.) J.Moravec, Mycotaxon 37:469,(1990).

Cheilymenia subhirsuta (Schum.) Boudier, Hist.Class.Discom.Eur.62,1907
= *Peziza subhirsuta* Schumacher, Flor. dan.tab.1787,fig.1. Notes: I was unable to locate the type collection of this taxon. I have examined two collections deposited in PC: Trento,Oct.1898 leg.Bresadola, and Val-d'Oise, Febr. 1899. These collections represent *Cheilymenia theleboloides* (Alb.et Schw.) Boud. and one of them might serve as a neotype. I have also been unable to locate the type of var. *hilaris* (Fr.) Boud. One collection from Boudier's herbarium deposited in PC and labelled " *Peziza subhirsuta* var. *hilaris* Fr., Nice,France,Martio 1883,D.Barla, and a collection from S herbarium "*Peziza subhirsuta* Fr. ß *hilaris*", Stockholm,XI.1891 leg. H. Kugelberg, represent also *C. theleboloides*. If *P. subhirsuta* and *P. theleboloides* are identical fungi, the oldes name, *P. subhirsuta* has priority.

Cheilymenia tandonia Thind et Kaushal, Indian Phytopath. 33:430, 1980.
Note: I requested the type from PAN three times but received no answer.

Cheilymenia vinacea (Rabenh.) Boudier,Hist.Class.discom.Eur.63,1907.
=*Peziza vinacea* Rabenhorst,Fungi Eur.exs.2314;Hedw.p.31,1878(S-holotype)
= ***Cheilymenia theleboloides*** (Alb.et Schw.) Boud.

Cheilymenia vitellina (Pers.) Dennis, Brit.Cup.Fungi p.27, 1960.
= *Peziza vitellina* Persoon, Myc.Europ.257,1822; :Fries, syst.mycol.2:84, 1822. (K-holotype) - nomen dubium.
=***Scutellinia umbrorum*** (Fr.) Lamb.,Fl.mycol.Belge,Suppl.1:300, 1887. Notes: the type (K) must be considered an unacceptable type for the taxon commonly recently interpreted as *C. vitellina*. *P. vitellina* may be the oldest name for *Peziza umbrorum* Fr. In the concept of species with coarsely warted ascospores, *P. vitellina* was adopted by Cooke (1879)and Rehm (1896) according to the collection from Mougeot herbarium, now K. This type material is labelled *P. vitellina* Pers. and represents *Scutellinia umbrorum*. T.Schumacher (1989) considers this material to be ssp. *sabulosa* Mough.:Pers.,Myc.Eur.257.1822, of *P. vitellina*. I consider the name *P. vitellina* a nomen dubium as this taxon cannot be clearly determined from the original description of *P. vitellina*, which differs nakedly from *S. umbrorum* in its present day sense. For these reasons and on the basis of my examination of the type collection of *Peziza oligotricha* Karst., I propose this later synonym to be the correct name for *Cheilymenia vitellina*: ***Cheilymenia oligotricha*** (Karst.) J.Mor. as transferred above. I have found this taxon identical with the type collection of *Peziza dalmeniensis* Cooke, which is a younger synonym of *C. vitellina* in the recent sense.

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MYCOTAXON

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OBSERVATIONS ON THE GENERA ASPROINOCYBE AND TRICHOLOSPORUM, AND DESCRIPTION OF A NEW SPECIES OF TRICHOLOSPORUM (AGARICALES, TRICHOLOMATACEAE)

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ABSTRACT

The genera *Asproinocybe* Heim and *Tricholosporum* Guzmán were compared in order to show that both are independent but closely related. *Asproinocybe* has subglobose tuberculate spores and laticifers, while *Tricholosporum* has stauriform or cruciatiform spores and probably lacks the laticifers. Both genera belong to the family Tricholomataceae, tribe Tricholomateae. Moreover, a new species of *Tricholosporum*, *T. longicystidiosum* Guzmán, Montoya & Bandala is described from a temperate zone of Mexico in the State of Morelos and new records of *T. subporphyrophyllum* Guzmán from the State of Oaxaca are presented.

INTRODUCTION

Tricholosporum Guzmán was established based on the unusual staurospores or cruciatespores and a vinaceous or violaceous pigmentation of the lamellae. The species recognized by Guzmán (1975) were: *T. goniospermum* (Bres.) Guzmán ex Baroni (the type) from Italy, *T. porphyrophyllum* (Imai) Guzmán ex Baroni from Japan, and *T. subporphyrophyllum* Guzmán from Mexico. Baroni (1982) also added *T. atroviolaceum* (Murr.) Baroni and *T. pseudosordidum* (Sing.) Baroni, both from U.S.A.

Asproinocybe Heim was defined by the subglobose tuberculate spores and the presence of laticifers (Heim, 1969-B). Heim (1969-A) first established the genus under the name *Leucinocybe* (*L. lactifera* Heim), without latin diagnosis, and afterwards (Heim, 1969-B) referred to it as *Asproinocybe*, because Singer (1943) had described the genus *Leucoinocybe* [*L. lenta* (R. Maire) Sing.] (non *Leucinocybe*), actually a synonym of *Mycena* (Singer, 1986). However, Singer (1986) and Heinemann and Thoen (1977) considered "*Leucoinocybe lactifera* Heim"(a misspelling of *Leucinocybe lactifera*) as a synonym of *Asproinocybe lactifera*. Heinemann and Thoen (1977) described *A. russuloides* Heinem. and *A. brunneolilacina* Thoen, and also redescribed *A. lactifera* Heim from Central Africa. On the other hand, Singer (1986) considered *A. ianthinocystis* (Sing.) Sing. (*Rhodocybe*, Sing.) from Argentina, although Baroni (1982) transferred it to *Omphaliaster*.

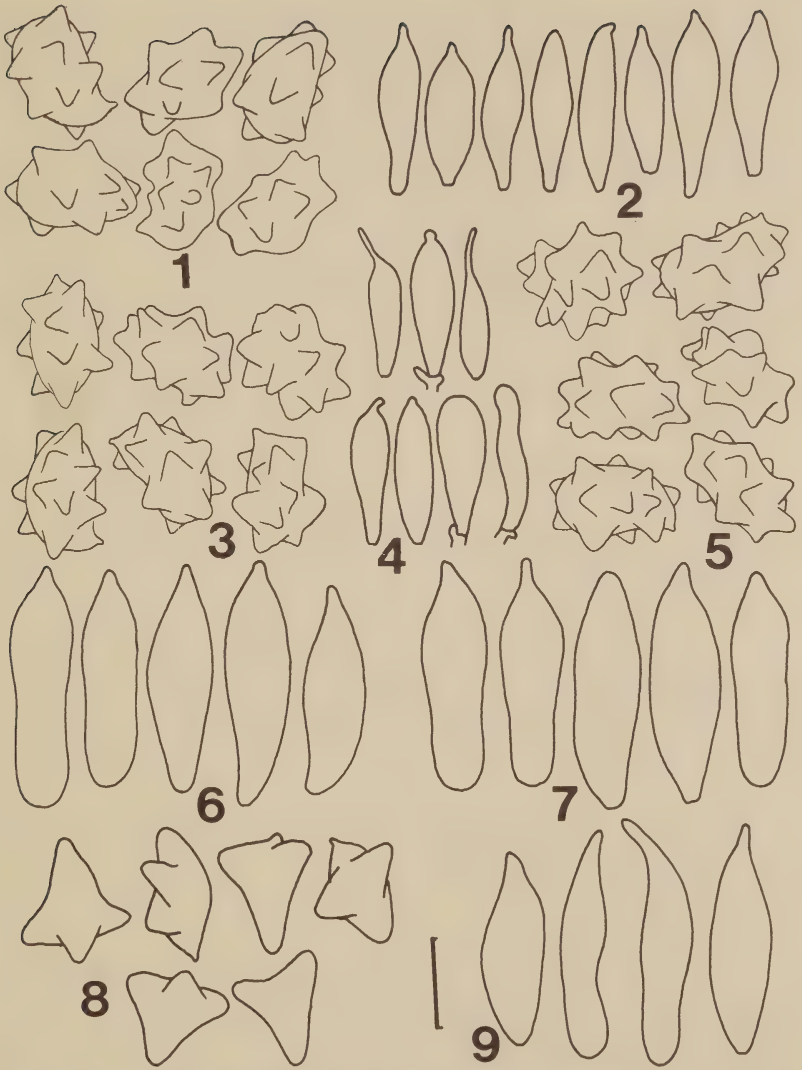
New collections of *Tricholosporum* from Mexico were studied by the authors of the present paper, examinating the type of *T. subporphyrophyllum* and comparing it with the types of the 3 species of *Asproinocybe*. A new species of *Tricholosporum* is described, and new records of *T. subporphyrophyllum* from Mexico are presented.

The specimens were studied according to the standard mycological techniques, using KOH 5 %, Melzer's solution and acetocarmine. Colors in parenthesis are based on the Kelly and Judd (1955) color chart.

TRICHOLOSPORUM GUZMAN VS. *ASPROINOCYBE* HEIM

These Tricholomataceous genera are closely related for the unusual spores shape among the Tricholomataceae and the vinaceous or violaceous pigmentation of the basidiocarp. The major differences between them are the stauriform or cruciatiform spores and probably lack of laticifers in *Tricholosporum*, versus the subglobose tuberculate spores and laticifers in *Asproinocybe*.

Tricholoma (Fr.) Staude (except Section Iorigida Sing., Singer,1945)generally lacks vinaceous or violaceous pigmentation and the spores are elliptic or subglobose never tuberculate, stauriform or cruciatiform, and lacks laticiferous hyphae.



Figs. 1-9.- *Tricholosporum* and *Asproinocybe*. 1-5: *A. lactifera*, 1: spores, 2: cheilocystidia (holotype). 3-4: *A. russuloides*, 3: spores, 4: pleurocystidia (holotype). 5: *A. brunneolilacina*, spores (holotype). 6-9: *T. subporphyrophyllum*, 6: pleurocystidia, 7: cheilocystidia (Guzmán 16181), 8: Spores, 9: pleurocystidia (Guzmán 16119) (Scale bar 5 µm for spores, 14 µm for cystidia).

Singer (1986) recognized Asproinocybe in the tribe Tricholomateae of the Tricholomataceae and he considered Tricholosporum to be a synonym of Tricholoma in the Section Iorigida, where he also places T. pseudosordidum Sing.(type of the section), T. goniospermum Bres., and T. porphyrophyrophyllum Imai, and "apparently also Tricholosporum subporphyrophyllum Guzmán and Gymnopus atrovirens Murr."

Bon (1984) considered Tricholosporum as a synonym of "sous-section Iorigida Sing.", and recently in Bon and Braiotta (1989), considered Tricholosporum as a subgenus of Tricholoma. Bohus (1982) described Tricholoma nodulosporum Babos & Bohus in the Section Iorigida. Alessio (1986) and Hongo (1988) did not discuss Tricholosporum when they treated Tricholoma goniospermum and T. porphyrophyllum, respectively.

Omphaliaster Lamoure is related to Tricholosporum and Asproinocybe because of spore development as discussed by Baroni (1982). Singer (1986) placed Omphaliaster in the Hygrophoraceae and Bigelow (according to Baroni, 1982) in Tricholomataceae.

Considering the similarities between Tricholosporum and Asproinocybe, the types of Asproinocybe lactifera, A. brunneolilacina and A. russuloides were studied, in order to determine the status of these genera. The relevant microscopic features observed in the types of Asproinocybe are the following:

A. lactifera Heim, holotype (PC). Leg. R. Heim LM-3024, forêt près de La Maboké, Republique Centrafricaine, May 1968.

Figs. 1-2

Spores (5-) 6-7 (-8) x 4-6 µm, subglobose to subellipsoid, tuberculate, hyaline, inamyloid. Basidia (20-) 23-32 (-35) x 8-10 µm, tetrasporic, not carminophilous. Pleurocystidia (18-) 20-33 (-38) x (5-) 6-8 µm, numerous but obscurely conspicuous, hyaline, cylindric-subfusoid, ventricose to clavate, slightly mucronate. Cheilocystidia (19-) 20-26 (-30) x (5-) 6-7 (-8) µm, similar to pleurocystidia. Hymenial trama regular, with hyaline, thin walled hyphae. Pileus cuticle of parallel hyphae, smooth, thin walled, hyaline but yellowish orange in groups. Laticifers frequent. Clamps commonly present.

A. russuloides Heinem., holotype (BR).Leg. Goossens-Fontana 3041, Zaïre, Forestier Central,Binga, October, 1944.

Figs. 3-4

Spores 6-8 x 5-6 μm, subglobose to subellipsoid, tuberculate, hyaline, inamyloid. Basidia tetrasporic, hyaline, not carminophilous, similar in size to cystidia. Pleurocystidia (8-) 12-24 (-28) x 4-8 μm, hyaline, fusoid, ventricose or subcylindric, frequently with a mucron or a thin and long apex or capitate. Cheilocystidia similar to pleurocystidia. Context trama regular, with hyaline, yellowish or yellowish brown, cylindric to subglobose hyphae. Laticifers common. Clamps present.

A. brunneolilacina Thoen, holotype (BR). Leg. Thoen 5227, Zaïre, Haut-Shaba, March, 1973.

Fig. 5

Spores 7-8 x 4-7 μm, subglobose to subellipsoid, tuberculate, hyaline, inamyloid. Basidia not observed. Cystidia absent. Epicutis with hyphae 4-8.8μm broad,loosely intermixed with granulate incrustations. Hymenial trama regular, hyphae 4-14.4 μm broad, hyaline. Laticifers common. Clamps commonly present.

It is interesting to note that the three species of *Asproinocybe* studied are macroscopically similar. All have convex-applanate pilei, with vinaceous brown colors and striate margins; lamellae with vinaceous or violaceous brown pigmentation, and whitish stipes, sometimes with vinaceous or violaceous brown tinges. Heinemann & Thoen (1977) differentiated the three species of *Asproinocybe* based on the context thickness, marginal striations and color "jaunâtre ± taché de bleu" in *A. lactifera*, "violet foncé ± nuancé de brun" in *A. russuloides*,and "brun violacé à brun noir" in *A. brunneolilacina*, features that may not be of taxonomical importance.

Our observations in *A. lactifera* and *A. russuloides* differ from those of Heinemann and Thoen 91977), who described the former species with carminophilous basidia (also Heim, 1969-A, B) and the later with pleurocystidia and cheilocystidia 23 x 6 μm. The other features in the 3 species agree well with our observations. The spores in the three species of *Asproinocybe* are similar. The significant differences among the species are the hymenial cystidia, which are absent in *A. brunneolilacina*, fairly large in *A. lactifera*, and shorter in *A. russuloides*.

Asproinocybe and *Tricholosporum* can be separated basically by the spores morphology, tuberculate in the former and cruciatiform in the later,as well as laticifers presence in *Asproinocybe*. Other characters such as hymenial cystidia and carminophilous basidia must be considered variable and more relevant interespecifically than generically. We conclude that the similarities between *Asproinocybe* and *Tricholosporum* indicate a close relationship and both are considered here as good genera in the Tricholomataceae, and the synonymy between *Tricholosporum* and *Tricholoma* is rejected.

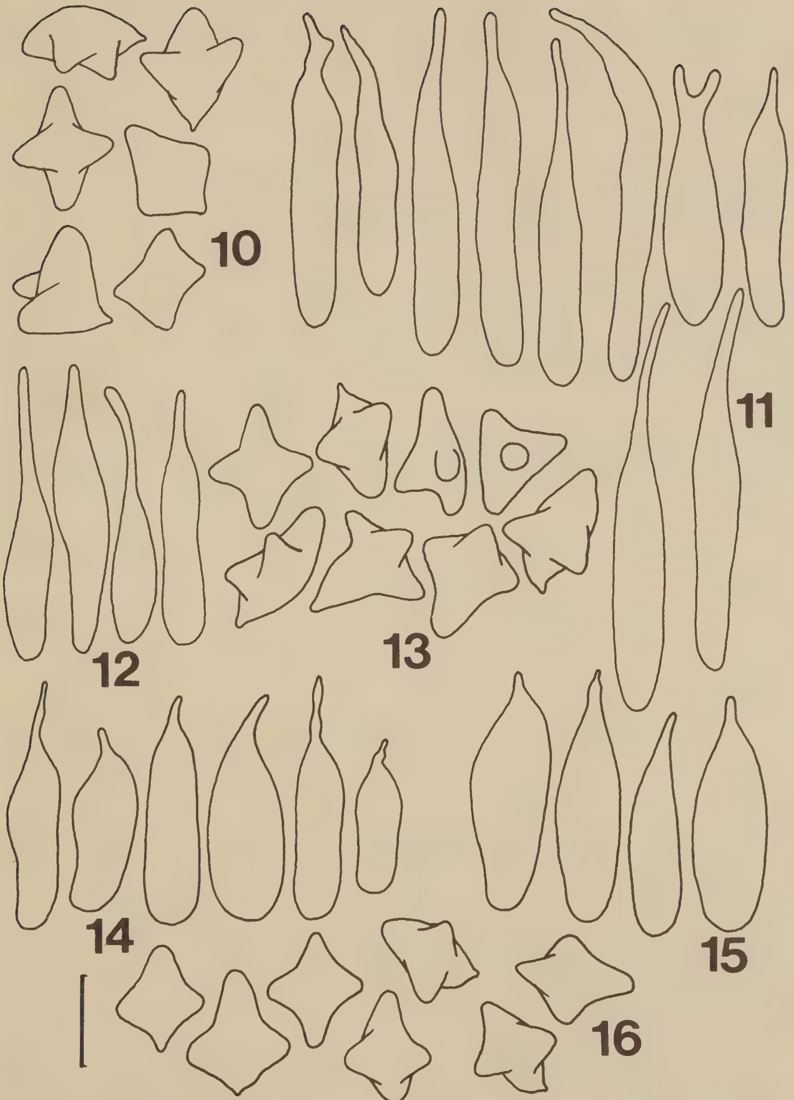
A NEW SPECIES OF *TRICHOLOSPORUM*

Tricholosporum longicystidiosum Guzmán, Montoya & Bandala, sp. nov.

Figs. 10-12

Pileus 70-160 mm latus, subconvexus vel plano-convexus, glabro, subviscidus, rufobrunneus vel fulvus. Lamellis adnexis, leucovinaceus vel rufovinaceus. Stipe 80-130 x 3-50 mm, cylindricus, subvelutinus vel glaber, carnous, concolor con pileus vel violaceus maculatum. Carne albida, odore et sapore leviter gratus. Sporis (4-) 5-7 x 4-6 μm, cruciformibus vel stauriformibus, hyalinis, inamyloideis. Pleurocystidia (28-) 30-65 x 5-9 (-12) μm, copiosus, subcylindraceus vel subfusiformis aut subclavatus mucronatus, apex tenuis et appendiculatus vel frequenter ramificatus, hyalinis vel vinaceus,tenuitunicates. Cheilocystidia (25-) 26.6-48.4 x 5.2-8 (-12) μm, copiosus,similis pleurocystidiis. Cutis gelificatis. Fibulis frequentis. Ad terram, caespitosus, zona temperata. Prope Tetela del Volcán, Morelos (Mexico). Leg. D. Portugal 89 (Holotypus ENCB, Isotypus XAL, NY).

Pileus 70-160 mm in diameter, subconvex or slightly convex-applanate, smooth, somewhat striate at the margin, subviscid, sometimes faintly cracked, vinaceous brown to yellowish brown (d. gy. Red 20, d. OY 72).Lamellae adnexed, sometimes slightly subdecurrent, close,pinkish to vinaceous brown (l.Pink 4, d.gy. Red 20), with smooth edges. Stipe 80-130 x 30-50 mm, cylindric, somewhat broadened downwards, subvelvety to glabrous towards the base, faintly sulcated or longitudinally striated, fleshy, compact, concolorous with the pileus, or with violaceous tinges.Context whitish, odor pleasant, taste mild.



Figs. 10-16.- *Tricholosporum*. 10-12: *T. longicystidiosum*, 10: spores, 11: pleurocystidia, 12: cheilocystidia (all from the holotype). 13-16: *T. subporphyrophyllum*,13:spores, 14: pleurocystidia, 15: cheilocystidia (all from the holotype), 16: spores (Guzmán 16181) (Scale bar 5 µm for spores, 14 µm for cystidia).

Spores (4-) 5-7 x 4-6 µm, stauriform or cruciate with conspicuous hilar appendix, thin-walled, hyaline, inamyloid. Basidia 35-46 x 5-7 µm, tetrasporic, clavate, hyaline or some with vinaceous-red tinges, not carminophilous. Pleurocystidia (28-) 30-65 x 5-9 (-12) µm, abundant, subcylindric to subfusoid or subclavate-mucronate to subventricose-mucronate, attenuated towards the apex or forming a long neck, frequently ramified, vinaceous-red or hyaline, thin-walled, necks projecting above hymenium level. Cheilocystidia (25-) 26.6-48.4 x 5.2-8 (-12) µm, numerous to scarce in some lamellae, similar in color and shape to pleurocystidia, thin-walled, necks projecting over the hymenium. Epicutis consisting of gelatinized intermixed hyphae, 2-4 µm broad, hyaline, thin-walled and smooth. Context of globose to subglobose cells 8-25 µm broad, hyaline, thin-walled. Hymenial trama subregular, hyphae 4-10 µm broad, frequently septated, thin-walled. Subhymenial layer with intermixed hyphae, 3-5 µm broad. The hymenium appearing pale vinaceous-red with some hyaline elements. Clamps common.

HABITAT. Terricolous and cespitose, growing in an apple orchard in a Pinus-Quercus zone.

SPECIMEN EXAMINED: MORELOS: Tetela del Volcán County, near Tetela del Volcán, D. Portugal 89 (HOLOTYPE, ENCB: ISOTYPES, XAL, NY).

DISCUSSION: T. longicystidiosum is characterized by the large basidiocarp (larger than T. subporphyrophyllum, which has pileus 20-57 mm in diameter), cespitose growth and hymenial cystidia morphology. It is grouped with the large spored species of the genus, such as T. goniospermum, T. porphyrophyllum and T. subporphyrophyllum. T. goniospermum differs by spores size (8-10 x 5-7 µm, Kühner & Romagnesi, 1953). T. porphyrophyllum lacks cystidia (Ito, 1959) and T. subporphyrophyllum has smaller basidiocarps and shorter cystidia [pleurocystida 19-37 (-41) x (3-) 5-13 µm and cheilocystidia 17-37 x 6-12 µm (figs. 6-9 & 13-16).

T. pseudosordidum and T. atroviolaceum are distinguished by smaller spores, 3.7-5.5 x 3-4.8 µm in the former (Singer, 1945) and 4-5.5 x 3-4 (-5) x 3-3.5 µm in the later (Baroni, 1982).

Bon and Braiotta (1989) considered Tricholoma tetragonosporum Maire as a form of T. goniospermum Bres. They described spores 5-6 (-8) x 4.5-5 (-6) µm, 5.5 x 4.5 µm and

7-10 x 5-6 µm, and cheilocystidia (25-) 30-60 (-70) x 2-3 (-5) µm.

FIRST RECORD OF TRICHOLOSPORUM SUBPORPHYROPHYLLUM IN THE STATE OF OAXACA (MEXICO)

Guzmán (1975) recorded *T. subporphyrophyllum* from the States of Morelos (type locality) and Tabasco, both in tropical rain forests. The material reported in Mora & Guzmán (1983) from Tetela del Volcán, Morelos, actually belongs to *T. longicystidiosum*.

Some collections made by Guzmán in 1976 in the State of Oaxaca (in ENCB) were studied by the authors and agree well with *T. subporphyrophyllum*, these being the first records of the species in this State. These collections are:

- Road from Ojitlan to Tuxtepec, Presa Cerro de Oro, August 3, 1976, tropical rain forest, 100 m alt., Guzmán 16181.

- 10 km to SW of Tuxtepec, Cerro Cebastopol, August 2, 1976, tropical rain forest, 100 m alt., Guzmán 16119.

ACKNOWLEDGEMENTS

The authors express their thanks to Instituto de Ecología for the support given to their researches. They also appreciate the colaboration of the directors of BR, ENCB and PC Herbaria for loan specimens. They also recognize the support of Sistema Nacional de Investigadores at Mexico City. Dr. Lorrain Giddings from Instituto de Ecología kindly improved the english text. The authors also acknowledge to Dr. P. Heinemann from Belgium who kindly revised critically this paper. Also thanks are given to Mrs. María Eugenia Ramírez López for typing this paper.

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MYCOTAXON

Volume XXXVIII, p. 497 July-September 1990

NOTICE

A NEW MYCOLOGICAL SOCIETY AND AN APPEAL FOR BOOKS AND JOURNALS

A new mycological society, the MYCOLOGICAL SOCIETY OF ROMANIA, has been formed, according to an announcement from Dr. M. Toma, forwarded to us by Mme. Françoise Candoussau.

The new society is anxious to obtain books and journals, to create the first mycological library in Romania. Prior to the recent political changes in that country, neither the society nor such a library could have been established.

All mycological publications will be gratefully received. Please address these to:

Dr. Mihai Toma
Institutul Agronomic
Catedra de Botanică
R–6600 Iasi–6
ROMANIA

MYCOTAXON

Volume XXXVIII, p. 498 July-September 1990

NOTICE

SOME FORTHCOMING MEETINGS

JOURNÉES MYCOLOGIQUES PHOCÉENNES

A meeting has been organized by the Muséum Naturelle d'Histoire Naturelle de Marseille in collaboration with the Société Mycologique de Provence and the Direction de l'École et des Espaces Verts at the Muséum Palais Longchamp, Marseille, France, from the 12th to 16th of November, 1990. The Bulletin d'Inscription may be obtained from, and must be returned by 15 September 1990 to:

Muséum d'Histoire Naturelle — Palais Longchamp
F–13004 Marseille
France

INTERNATIONAL SYMPOSIUM IMPROVING THE STABILITY OF NAMES: NEEDS AND OPTIONS

Advance notice has been received of an international symposium on improving stability of names of plants and fungi, organized by the International Union of Biological Sciences, the International Association for Plant Taxonomy, and the Systematics Association, to take place 21-23 February 1991. It will be held at the Royal Botanic Gardens, Kew

"The stability of the names of organisms is one of the most common complaints made against taxonomists, and must be addressed to retain the subject's credibility. Special Committees established under the auspices of the General Committee on Botanical Nomenclature are currently considering methods of improving the stability of names of all groups covered by the International Code of Botanical Nomenclature. These options include the production of Lists of Names in Current Use, and procedures for registration of newly introduced names and(or) publications. Many users feel these proposals do not go far enough, while some taxonomists feel they go too far. Proposals made will be voted on at the International Botanical Congress in 1993, but as these could lead to the most fundamental changes in biological nomenclature since Linnaeus, a frank, open and thorough debate of the needs and options is essential."

For further information and registration details, write:

Professor D. L. Hawksworth
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Ferry Lane, Kew, Surrey TW9 3AF, UK
[Telephone (081) 940-4086; Fax (081) 332-1171]

MYCOTAXON

Volume XXXVIII, p. 499 July-September 1990

NOTICE

APPOINTMENT OF AN EDITORIAL ADVISORY BOARD

MYCOTAXON, LTD. announces the formation of an *Editorial Advisory Board*, effective July 1, 1990. Six eminent mycologists have agreed to serve as the first Board, with staggered terms of office from one to six years in length, as follows:

OVE E. ERIKSSON, Umeå, Sweden (1990-93)
GRÉGOIRE L. HENNEBERT, Louvain-la-Neuve, Belgium (1990-96)
JAMES W. KIMBROUGH, Gainesville, Florida (1990-91, *Chm.*)
RONALD H. PETERSEN, Knoxville, Tennessee (1990-94)
JACK D. ROGERS, Pullman, Washington (1990-92)
AMY Y. ROSSMAN, Beltsville, Maryland (1990-95)

The Editorial Advisory Board will monitor the editorial policies of MYCOTAXON and will make appropriate suggestions for improvements and possible changes to the current Co-Editors and to the new Editor-in-Chief who will take office beginning with volume 41 (see separate announcement in this issue), and will also offer advice to such Editors on any policies referred to them by the Editors or by subscribers. They will also annually advise the Board of Directors of MYCOTAXON, LTD., the corporation financially responsible for the journal, on the status of editorial practices in the journal, and, when necessary, shall nominate for corporate consideration a replacement for a retiring Editor-in-Chief.

The Editorial Advisory Board is a self-perpetuating body. One member normally will retire each year (but may be re-elected to additional 6-year terms). That member who is expected to retire at the end of the following year will serve as Chairman of the Board during his or her final year. All members of the Board vote on a slate of candidates prepared by the Chairman (proposals are by any Board member) to replace the retiring member. Vacancies are filled by special ballot to complete a term of office.

MYCOTAXON

Volume XXXVIII, p. 500 July-September 1990

NOTICE

FORTHCOMING MAJOR EDITORIAL CHANGES

MYCOTAXON will undergo major editorial changes effective with volume 41, scheduled for production in early 1991.

On the completion of volume 40, one of the founding Co-Editors, Richard P. Korf, will step down both as *Managing Editor* and as *English Language Editor*, having served in these posts since 1973. Similarly, Susan C. Gruff, who has served since 1980 as *Assistant Editor* and then as *Associate Editor*, and as *Index Editor* since 1982, will also relinquish her duties at that time. The other founding Co-Editor, Grégoire L. Hennebert, wearing two hats since 1973, will continue as *French Language Editor*, but will relinquish his position as *Book Review Editor*, again effective with volume 41.

MYCOTAXON, LTD. is pleased to announce that Dr. Jean R. Boise, Harvard University Herbaria, 22 Divinity Avenue, Cambridge, Massachusetts 02138, has accepted appointment to the new post of *Editor-in-Chief* of MYCOTAXON, effective with volume 41. Please note that all manuscripts submitted after 1 October 1990 should be sent to her directly (except in the case of manuscripts written in French, which should continue to go first to Dr. Hennebert). Dr. Boise has been delegated very broad editorial powers to institute new or revised editorial procedures and to appoint those she wishes to have serve her as Associate Editors.

Dr. Boise has now appointed a new *Book Review Editor*, Prof. Linda M. Kohn, Botany Department, University of Toronto – Erindale, Mississauga, Ontario L5L 1C6, Canada, effective with volume 41. All books for review should now be addressed directly to Dr. Kohn..

Also appointed by Dr. Boise to begin duties with volume 41 as *Index Editor* is Robert Dirig, Bailey Hortorium, Cornell University, Ithaca New York 14853.

Drs. Hennebert and Kohn, and Mr. Dirig, have all been appointed as *Associate Editors* of MYCOTAXON by Dr. Boise.

The Editorial Advisory Board to MYCOTAXON and to its corporate complement, MYCOTAXON, LTD., announced elsewhere in this issue, will, of course, continue in its advisory capacity to the Editor-in-Chief and to the Board of Directors of the corporation.

AUTHOR INDEX, VOLUME THIRTY-EIGHT

Abdul–Wahid, O. A., see **Moustafa and Abdul–Wahid**
Abdullah, N., see **Ho & al.**
Adler, Mónica T., An artificial key to the genera of the Parmeliaceae (Lichenes, Ascomycotina) 331-347
Agerer, Reinhard, see **Treu and Agerer**
Anon., NOTICE: A new mycological society and an appeal for books and journals 497
Anon., NOTICE: Appointment of an Editorial Advisory Board 499
Anon., NOTICE: Forthcoming major editorial changes 500
Anon., NOTICE: Some forthcoming meetings 498
Arambarri, Angélica, see **Cabello & al.**
Arambarri, Angélica, see **Cazau & al.**
Arambarri, Angélica, and Marta Cabello, Considerations about *Dictyochaeta*, *Codinaeopsis* and a new genus, *Dictyochaetopsis* 11-14
Bandala, Victor M., see **Guzmán & al.**
Bandala, Victor M., see **Montoya & al.**
Bauchop, T., see **Ho & al.**
Cabello, Marta, see **Arambarri and Cabello**
Cabello, Marta, see **Cazau & al.**
Cabello, Marta, Cecilia Cazau, and Angélica Arambarri, New hyphomycetes from Santiago River. III. (Buenos Aires Province, Argentina) 15-19
Cano, J., J. Guarro, and L. Zaror, Two new species of *Aphanoascus* (Ascomycotina) 161-166
Castellano, Michael A., The new genus *Trappea* (Basidiomycotina, Hysterangiaceae), a segregate from *Hysterangium* 1-9
Cazares, Efren, and James M. Trappe, Alpine and subalpine fungi of the Cascade Mountains. I. *Hymenogaster glacialis* sp. nov. 245-249
Cazau, Cecelia, see **Cabello & al.**
Cazau, Cecelia, Angélica Arambarri, and Marta Cabello, New hyphomycetes from Santiago River. IV. (Buenos Aires Province, Argentina) 21-25
Danell, Eric, and Nils Fries, Methods for isolation of *Cantharellus* species, and the synthesis of ectomycorrhiza with *Picea abies* 141-148
Demoulin, V., and M. Lange, *Calvatia turneri* (Ellis et Everh.) Demoulin et M. Lange, comb. nov., the correct name for C. *tatrensis* Hollós 221-226
Eriksson, Ove E., and Jing–zhu Yue, Notes on bambusicolous pyrenomycetes. Nos. 1–10 201-220
Fries, Nils, see **Danell and Fries**
Gams, W., R. Steiman, and F. Seigle–Murandi, The hyphomycete genus *Goidanichiella* 149-159
Guarro, J. see **Cano & al.**
Guzmán, Gastón, see **Montoya & al.**
Guzmán, Gastón, Leticia Montoya, and Victor M. Bandala, Observations on the genera *Asproinocybe* and *Tricholosporum*, and description of a new species of *Tricholosporum* (Agaricales, Tricholomataceae) 485-495
Hansen, Eric Steen, Additions to the lichen flora of Iceland 133-139
Harrington, Francis A., *Sarcoscypha* in North America (Pezizales, Sarcoscyphaceae)

417-458
Harrington, T. C., and P. J. Zambino, *Ceratocystis ranaculosus*, not *Ceratocystis minor* var. *barrasii*, is the mycangial fungus of the southern pine beetle 103-115
Heykoop, Michel, see **Illana & al.**
Ho, Y. W., T. Bauchop, N. Abdullah, and S. Jalaludin, *Ruminomyces elegans* gen. et sp. nov., a polycentric anaerobic rumen fungus from cattle 397-405
Illana, Carlos, Michel Heykoop, and Gabriel Moreno, Contribution to the study of the myxomycetes in Spain. III. Catalogue of myxomycetes of Spain 37-69
Jalaludin, S., see **Ho & al.**
Keil, C. B., see **Miller and Keil**
Kendrick, Bryce, A rapid, computer-based synoptic key to genera of gilled fungi 27-36
Lange, M., see **Demoulin and Lange**
Lumbsch, Helge Thorsten, and Helmut Mayrhofer, A new *Diploschistes* species (lichenized Ascomycetes, Thelotremataceae) from India 311-313
Mayrhofer, Helmut, see **Lumbsch and Mayrhofer**
Meijer, A. R. de, see **Rajchenberg and de Meijer**
Miller, M. W., and C. B. Keil, Redescription of *Pandora gloeospora* (Zygomycetes: Entomophthorales) from *Lycoriella mali* (Diptera: Sciaridae) 227-231
Montoya, Leticia, see **Guzmán & al.**
Montoya, Leticia, Gastón Guzmán, and Victor M. Bandala, New records of *Lactarius* from Mexico and discussion of the known species 349-395
Moore, Royall T., The genus *Lalaria* gen. nov.: Taphrinales anamorphosum 315-330
Moravec, Jiří, Taxonomic revision of the genus *Cheilymenia* — 3. A new generic and infrageneric classification of *Cheilymenia* in a new emendation 459-484
Moreno, Gabriel, see **Illana & al.**
Moustafa, A. F., and O. A. Abdul–Wahid, *Veronaea constricta*, a new hyphomycete from Egyptian soils 167-171
Parker, Alan D., Noteworthy species of *Hypocrea*, *Hypomyces*, and *Thuemenella* (Ascomycetes, Hypocreales) from Wisconsin 77-82
Parmasto, Ilmi, Spores of *Aleurodiscus amorphus* 241-243
Rajchenberg, Mario, and André A. R. de Meijer, New and noteworthy polypores from Paraná and São Paulo States, Brazil 173-185
Ryvarden, Leif, Type studies in the Polyporaceae – 22. Species described by C. G. Lloyd in *Polyporus* 83-102
Schumacher, Trond, New or noteworthy discomycetes. 1. Some stromatic fungi on *Alnus* or *Betula* 233-239
Seigle–Murandi, F., see **Gams & al.**
Simmons, Emory G., *Embellisia* and related teleomorphs 251-265
Spain, Joyce Lance, Arguments for diagnoses based on unaltered wall structure 71-76
Steiman, R., see **Gams & al.**
Trappe, James M., see **Cazares and Trappe**
Treu, Roland, and Reinhard Agerer, Culture characteristics of some *Mycena* species 279-309
Tulloss, Rodham E., *Amanita salmonescens* — a new species from the southeastern United States 125-132

Vánky, Kálmán, Taxonomical studies on Ustilaginales. VI 267-278
Wolfe, C. B., Jr., Type studies in *Tylopilus*. IV. Taxa described by Rolf Singer. 1. 187-200
Yang, Zhu–liang, Several noteworthy higher fungi from southern Yunnan, China 407-416
Yue, Jing–zhu, see **Eriksson and Yue**
Zambino, P. J., see **Harrington and Zambino**
Zaror, L. see **Cano & al.**
Zhuang, Wen–ying, *Calycellinopsis xishuangbanna* gen. et sp. nov. (Dermateaceae), a petiole–inhabiting fungus from China 121-124
Zhuang, Wen–ying, A new combination in *Parencoelia* 117-119

REVIEWERS, VOLUME THIRTY-EIGHT

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INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME THIRTY-EIGHT

This index contains the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface,** as are the page numbers on which such new taxa are proposed.

Abortiporus
  biennis 85
Acarospora
  smaragdula 137
Acarosporium 237
  quisquiliaris 237
  sympodiale 237, 238
Acaulospora 73
  morrowae 74
Agaricus
  aspratus 409
  bisporus 227
  brunnescens 227, 229
  nigripes 413
  phlyctaenodes 414
Ahtia 333
Albatrellus
  cantharellus 85
  dispansus 88
  yasudai 102
Aleuria
  rhenana 453
  rutilans 451
Aleurodiscus
  amorphus 241
Allewia 251, **260**, 262, 265
  eureka 251, 260, **264**
  proteae 251, 258, 260, **262**-264
Alternaria 251, 252, 260
  dennisii 257
  eureka 258, 260
Amanita 32, 34, 130, 280, 304, 305
  sect. Lepidella 125, 130-132
  sect. Validae 125, 130-132
  canescens 132
  media 130, 131
  nitida 132
  radiata 130, 131
  rubescens
    var. alba 132
  salmonescens **125**-127, 129-132
Amaurochaete
  atra 38
Amauroderma 84, 101
  boleticeum 95
  calcigenum 85, 99
  camerarium 91, 175
  conicum 83, **88**
  conjunctum 88
  expallens 88
  fasiculatum 99
  longipes 88
  oblongisporum 89, 101
  preussii 85, 97, 102
  rude 97
  rugosum 84, 97
  schomburgkii 95, 175
  sprucei 88, 175
  subrugosum 92, 93
  unilaterum 83, 100, **101**
Amphisphaeria 212
Amylocystis
  lapponica 101
Amylosporus
  campbellii 92, 93, 95
Antennularia
  chusqueae 207
Anthostomella 211, 212
Anthracoidea
  liroi 267
Antrodia 85
  conchata 85
  malicola 175
  similis 84
Antrodiella 176
  angulatopora 173, 175
  murrillii 83, **93**, 94
Aphanoascus 161
  australis **161**, 162
  hispanicus 166
  keratinophilus 162
  punsolae 161, **162**, 164, 166
  reticulisporus 162
  saturnoideus 162
  terreus 166
  verrucosus 162
Aporpium
  substuppeus 91
Arctoparmelia 334
Arcyria
  affinis 38
  annulifera 38
  carnea 38
  cinerea 38
  denudata 38
  ferruginea 40
  flava 40
  gulielmae 38
  incarnata 40
  insignis 40
  leiocarpa 40

[Arcyria] major 40
  nutans 40
  obvelata 40
  oerstedtii 40
  pomiformis 40
  punicea 38
  versicolor 40
Armillariella 306
Arrhenia
  fimicola 469, 481
Arthrinium 212
Asahinea 334, 338
  chrysantha 334
Ascobolus
  insignis 476
  pulcherrimus 475
Ascophanus
  flavus 474
  striatus 474
Aspergillus 149
Aspicilia
  caesiocinerea 133, 134, 137
Asproinocybe 485-490
  brunneolilacina 486-489
  ianthinocystis 486
  lactifera 486-489
  russuloides 486-489
Asteridium
  chusqueae 207
Athiana 335
Aurificaria
  indica 95, 99
  poncei 95
Australoporus
  tasmanicus 99

Badhamia
  affinis 41
  capsulifera 41
  dearnessii 41
  dubia 41
  dubia 41
  foliicola 41
  gracilis 41
  macrocarpa 41, 57
  nitens 41
  ovispora 41
  panicea 41
  utricularis 41
  versicolor 41
Badhamiopsis
  ainoae 42
Bjerkandera
  adusta 84, 175
Boedijnopeziza
  colensoi 452
Boletus
  felleus
    var. minor 190
Bondarzewia
  berkeleyi 95
Bovista 85, 88
Brodoa 332
Broomella
  miakei 201, 209
Bulbothrix 339
Bulgaria 438
Byssothecium 216

Caecomyces
  equi 397
Caeoma
  zeae 274
Calomyxa
  metallica 42
Calonema
  luteolum 42
Caloplaca
  crenularia 133, 134
  fraudans 133, 134
Calosphaeria 214
  (rank?) Togninia 213, 214
  inconspicua 201, 213, 214
Calvatia 223
  arctica 221
  cretacea 221, 223
  tatrensis 221, 223
    var. groenlandica 222
  turneri 221-**223**
Calycellina 122
Calycellinopsis **121**, 122
  xishuangbanna **121**, 122
Candelariella
  vitellina 134
Candida 318
  albicans 156
  glabrata 156
  parapsilosis 156
  tropicalis 156
Canomaculina 342
Canoparmelia 339
  carneopruinata 339
  crozalsiana 339
  texana 339
Cantharellus 141
  cibarius 141-147
  pallens 141-144
  tubaeformis 142, 144
Ceratiomyxa
  fruticulosa 42
    var. porioides 42
  porioides 42
  sphaerosperma 42

- Ceratocystiopsis 109
  - ranaculosus 103-110, 112-114
- Ceratocystis
  - minor
    - var. barrasii 103-105, 107, 108, 113, 114
    - var. minor 103
- Cerebella
  - andropogonis 275
  - andropogonis-finitimi 275
  - paspali 275
- Ceriporia 179
  - xylostromatoides 175
- Ceriporiopsis 175
  - gilvescens 175
  - latemarginata 173, 175
  - rivulosa 175
- Cerrena
  - **cystidiata** 173, **176**, 177
  - unicolor 176
- Cetraria 331, 343
  - ciliaris 336
  - pallidula 332
- Cetrariastrum 341
- Cetrariopsis 333
- Cetrelia 337
- Cetreliopsis 333
- Chaetosphaeria
  - dingleyae 13
- Cheilymenia 459, 460, 462-468, 471-473, 477, 478, 480, 482
  - sect. Cheilymenia 459, 462, 465, 467, 469, 472, 476, 479
  - sect. **Coprobiae** 459, 462, 463, 466, 468, 471, **474**, 478, 482
  - sect. **Insigniae** 459, 462, **476**, 479
  - sect. **Micropilosae** 459, 462, 467, 469, 471, **475**, 479
  - sect. **Paracheilymeniae** 459, 462, 467, 469, 472, **475**, 479
  - sect. **Pseudoscutelliniae** 459, 462, 465, 467, 469, 472, **477**, 480
  - sect. **Raripilosae** 459, 462, 467, 469, 472, **476**, 479
  - sect. **Striatisporae** 459, 462-464, 466, 468-471, **474**, 478
  - sect. **Villosae** 459, 462, 467, 469, 471, **475**, 478, 482
  - ser. Cheilymenia 459, 462, 465, 467, 469, 472, 476, 479
  - ser. **Coprinariae** 459, 462, 467, 469, 472, **477**, 480
  - ser. **Fuscae** 459, 462, 469, 472, **477**, 480
  - ser. **Obtusipilosae** 459, 462, 467, 469, 471, **475**, 479, 482
  - ser. **Pallidae** 459, 462, 467, 469, **476**, 479, 480
  - ser. **Pseudoscutelliniae** 459, 462, 465, 467, 469, **477**, 480
  - ser. **Striatisporae** 459, 462, 463, 466, 468, 470, 471, **474**, 478
  - ser. **Tenuistriatae** 459, 462, 464, 466, 469-471, **475**, 478
  - ser. **Villosae** 459, 462, 467, 469, 471, **475**
  - alleghenensis 480
  - alpina 480
  - ascoboloides 480
  - asteropila 462, 469, 472, 476
  - aurantiacorubra 462, 469, 472, 476
  - aurea 480
  - bisetosa 481
  - **bohemica** 462, **476**, 481
  - cadaverina 462, 467, 469, 472, 477
  - calvescens 481
  - ciliata 474, 481, 483
  - citrinella 461, 462, 466, 469, 475, 478
  - coprinaria 460, 462, 467, 469, 477, 480, 481
  - coprogena 462, 469, 476
  - **crassistriata** 462, 468, 471, **474**
  - crucipila 481
  - dalmeniensis 481
  - fimicola 462, 469, 477, 481
  - flava 474, 481
  - fraudans 462, 477
  - gemella 462, 469, 471, 475, 483
  - glumarum 481
  - **granulata** 459, 462, 463, 466, 468, **474**, 480, 481
  - humarioides 462, 469, 477
  - hyalochaeta 482
  - hyphopila 482
  - insignis 462, 476
  - **karstenii** 462, 468, **474**
  - lemuriensis 461, 462, 468, 474
  - lentiformis 482
  - liskae 462, 477
  - **magnifica** 462, 467, 469, 471, **474**, 482
  - magnipila 462, 465, 467, 469, 472, 477
  - megaspora 462, 477
  - micropila 482
  - notabilispora 472, 482
  - **oligotricha** 461, 462, 464, 466, 469-471, **475**, 481, 483
  - pallida 462, 467, 469, 476, 480
  - **pediseta** 461, 462, 466, 469, **475**
  - pseudohumarioides 462, 477
  - pulcherrima 462, 467, 469, 476
  - raripila 460, 462, 467, 469, 472, 476,

482
[Cheilymenia] rubra 460, 462, 467, 469, 477, 480-482
  sordida 462, 468, **474**
  stercoraria 462, 467, 469, 471, **475**, 479, 482
  stercorea 460, 462, 465, 467, 469, 472, 473, 476, 479-483
  striata 462, **474**
  subhirsuta 483
  tandonia 483
  theleboloides 459-463, 466, 468, 470, 471, 474, 480-483
  villosa 462, 467, 469, 471, 475
  vinacea 483
  vitellina 461, 483
Chondrioderma
  globosum 46
Chromocreopsis 80
  cubispora 80
Chrysosporium 162, 166
  indicum 166
  tropicum 162
Ciboria
  conformata 233
  pachyderma 234, 236, 237
  rufescens 234-236
  sejournei 236
  violascens 233
Ciboriella 235
  rufescens 234
Cienkowskia
  reticulata 42
Cintractia
  caricis 274
  kusanoana 273
  liroi 274
Cladina 143
Clastoderma
  debaryanum 42
  pachypus 42
Claterosporium
  pedunculatum 19
Clavaria
  capucina 409
  xylogena 409
Coccodiella
  arundinariae 202, 203
Coccoidea 205
Coccostromopsis
  arundinariae 202
Codinaea 11, 13, 14
  apicalis 12, 13
  assamica 14
  dingleyae 12
  elegantissima 12, 13
  filamentosa 12, 13
  glauco-nigra 12, 13
  gonytrichoides 11, 13
  intermedia 13
  maharashtrensis 13, 14
Codinaeopsis 11, 13, 14
Collaria
  arcyrionema 42
  elegans 42
  lurida 42
  rubens 42
Colloderma
  macrotubulatum 42
  oculatum 42
Coltricia
  duporti 173, 177
  montagnei 89
  vallata 95
Coltriciella
  dependens 88
  oblectabilis 178
Comatricha
  alta 43
  dictyospora 43, 60
  elegans 43
  ellae 43
  friesiana 43
  laxa 43
  lurida 43
  nigra 43
  pulchella 43, 60
  rigidiretta 43
  subcaespitosa 43
  suksdorfii 43
  tenerrima 44
  typhina 60
  typhoides 60
Concamerella 341
Cookeina
  colensoi 408, 437, 452
  indica 407, 410
  sulcipes 427
  tetraspora 454
  tricholoma 427, 454
  venezuelae 408
Coprobia 459-461, 473, 474, 478
  bohemica 481
  crassistriata 474
  flava 474
  granulata 460, 474
  humana 482
  magnifica 475, 482
  pileiformis 482
  sordida 474
Cordana
  parvispora 24
Coriolopsis

  - asper 89, 97, 102
  - badius 101
  - floccosa 97
  - fulvocinerea 89
  - polyzona 178
  - rigida 178
  - sanguinaria 85, 97
  - strumosa 89
- Craterium
  - aureum 44
  - leucocephalum
    - var. leucocephalum 44
    - var. scyphoides 44
  - minutum 44
  - rubronudum 44
- Crepidotus 78
- Cribraria
  - argillacea 44
  - aurantiaca 44, 45
  - cancellata
    - var. cancellata 44
    - var. fusca 44
  - candida 44
  - macrocarpa 44
  - microcarpa 44
  - minutissima 45
  - mirabilis 45
  - persoonii 45
  - piriformis 45
  - rufa 45
  - splendens 45
  - tenella 45
  - violacea 45
  - vulgaris
    - var. aurantiaca 44
    - var. oregana 45
    - var. vulgaris 45
- Cryptococcus 316
  - neoformans 156
- Cryptosporella 213
  - bambusicola 213
  - hypodermia 213
- Cryptotrama
  - asprata 407, 409, 410
- Cyathicula
  - quisquiliaris 237
- Cyathus
  - striatus 77, 78
- Cyclomyces
  - tabacinus 89

- Dactylaria 21
  - acerina 24
  - **appendiculata** **21**, 22
  - **argentina** 21, 22
  - **longidentata** 21, **22**
  - parvispora 21, 22, 24
- Dermatea
  - kalmiae 117
- Diachea
  - leucopodia 45
  - radiata 45
  - subsessilis 45
- Diacheopsis
  - nannengae 45
- Dianema
  - corticatum 45
  - harveyi 45
- Dichomitus
  - squalens 101
- Dictydiaethalium
  - ferrugineum 46
  - plumbeum 46
- Dictydium
  - cancellatum 44
  - mirabile 45
  - rutilum 46
- Dictyochaeta 11-14
  - fuegiana 11
  - menisporoides 11, 13, 14
- **Dictyochaetopsis** 11, **12**, 14
  - **apicalis** **12**
  - **dingleyae** **12**
  - **elegantissima** **12**
  - **filamentosa** **12**
  - **glauco-nigra** **12**
  - **intermedia** **12**
  - **maharashtrensis** **13**
  - **menisporoides** **13**
- Dictyopanus 306
- Diderma
  - alpinum 46
  - asteroides 46
  - cinereum 46
  - chondrioderma 46
  - darjeelingense 46
  - floriforme 46
  - fragilis 46
  - globosum 46
  - hemisphaericum 46
  - lyalii 46
  - montanum 46
  - niveum 46, 47
  - platycarpum 46
  - radiatum 47
  - rufoestriatum 47
  - spumarioides 47, 55
  - subsesylis 45
  - testaceum 47
  - trevelyani
    - var. nivale 47
    - var. trevelyani 47
  - umbilicatum 46, 47

Didymium
  anellus 47
  bahiense 47
  clavus 47
  comatum 47
  crustaceum 47
  difforme 47
  dubium 48
  eximium 48
  farinaceum 48
  iridis 48
  karstensii 48
  laxifila 48
  marineri 48
  megalosporum 48
  melanospermum
    var. bicolor 48
    var. melanospermum 48
  minus 48
  muscorum 48
  nigripes 48
  ovoideum 48
  quitense 49
  serpula 49
  squamulosum 49
  sturgisii 49
  trachysporum 49
  tubulatum 49
  vaccinum 49
  verrucosporum 49
Diploschistes 311, 313
  actinostomus 311, 313
  areolatus 311
  caesioplumbeus 311, 313
  diploschistoides 313
  megalosporus **311**-313
Dothidea
  kalmiae 118, 119

Earliella
  scabrosa 178
Echinoporia
  aculeifera 178
Echinostelium
  apitectum 49
  arboreum 49
  brooksii 49
  coelocephalum 49
  colliculosum 49
  corynophorum 49
  cribrarioides 50
  elachistan 50
  fragile 50
  minutum 50
Elvela
  coccinea 443, 446
  lentiformis 473, 482
  lutea 482
Embellisia 251, 252, 254, 258, 260, 262, 264, 265
  abundans 264
  allii 254, 264
  dennisii 251, 256, **257**, 259
  eureka 251, **260**, 264
  leptinellae 251, **254**-257
  novae-zelandiae 251, **252**-254, 257
  phragmospora 264
  planifunda 254
  proteae 251, **258**, 260-262
  telluster 254
Enerthenema
  melanospermum 50
  papillatum 50
Enteridium
  intermedium 50
  liceoides 50
  lycoperdon 50
  olivaceum 50, 51
  splendens
    var. juranum 50
Entomophthora
  gloeospora 228
Entrophospora
  colombiana 74
Entyloma 275
  dactylidis 275
Epichloë 206
  typhina 206
Epicoccum
  andropogonis 267, 275
Epidermophyton
  floccosum 156
Epilichen
  scabrosus 133, 136
Erostella
  inconspicua 213
Erynia
  gloeospora 227, 228, 231
Esslingeriana 337
Eutypa 211
Everniastrum 336, 342
  americanum 336

Favolaschia
  pustulosa 410
  tonkinensis 407, 410
Favolus 84
  brasiliensis 178
  moluccensis 84
  spatulatus 84
  tessellatus 178
Fimaria
  bohemica 476, 481

  humana 482
Flammulina 306
Flaviporus 176, 183
  brownei 178
  cystidioides 88
  hydrophilus 178
  liebmanni 178
Flavoparmelia 335, 336
Flavopunctelia 333
  soredica 333
Fomitella
  supina 178
Fomitopsis
  meliae 178
  nivosa 89
  palustris 97
  rhodophaea 99
Fuligo
  cinerea 51, 54
  septica 50
    var. candida 51
    var. flava 51
    var. septica 51
    var. violacea 51
  varians 51
Furia 230
  montana 227, 230
  sciarae 227, 230
Fuscocerrena
  portoricensis 178

Galeoscypha
  pileiformis 482
Ganoderma 84, 98, 101
  amboniense 95
  applanatum 78, 79
  capensis 85
  coffeatum 91
  dorsale 88
  lucidum 85, 88, 89, 95, 178
  nigrolucidum 95
  parvulum 178
  subfornicatum 178
  tornatum 178
  tsugae 92
Geopyxis
  coccinea 443
  hesperidea 448
  majalis 437
  occidentalis 448
  vulcanalis 452
Ginanniella 271
Gliocephalis 149, 150
  hyalina 150
  pulchella 150
Gliocladium
  pulchellum 150
Gloeophyllum
  striatum 178
Gloeoporus
  dichrous 178
Gloiosphaera 151
  clerciana 151
  globuligera 151
  minor 151
Glomus
  aggregatum 75
  pansihalos 72, 74
Goidanichia 149, 150
  scopula 150, 151
Goidanichiella 149-**152**, 156
  barronii 149, **152**, 153, 155, 157
  sphaerospora 150, 157
Grammothele
  subargentea 178
Grifola
  colensoi 93
Gymnopus
  atrovirens 488

Hapalopilus
  nidulans 97
Haplographium 149-151
  catenatum 151
Helminthosporium
  attenuatum 19
  pedunculatum 19
Helotium
  conformatum 233
  umbrinum 235
Helvella 452
  corium 452
  macropus 437
Hemitrichia
  abietina 51
  calyculata 51
  clavata 51
  leiotricha 51
  serpula 51
  vesparium 54
Henningsia 178
  brasiliensis 173, 178
Heteroporus
  biennis 179
Hexagonia
  hydnoides 179
  papyracea 179
Humaria 473
  alpina 480
  anceps 480
  flava 474, 481
  granulata
    var. robusta 468, 481

[Humaria] hirtella
    f. minor 481, 482
  stercoraria 475, 482
  stercorea
    var. aurantiaco-flava 480
Humariella 473
Hyaloscypha
  dematiicola 151
Hymenogaster 245, 247
  gilkeyae 247
  glacialis 245, **246**-248
Hymenoscyphus 235
  rufescens 233, **234**
Hypocrea 77
  cubispora 80
  latizonata 77
Hypomyces 77
  chrysostomus 77-79
  tremellicola 77, 78
Hypotrachyna 334, 336, 338
Hysterangium 1-3, 6
  darkeri 2, 3
  membranaceum 6
  phillipsii 1, 2, 7

Imshaugia 338
Inonotus 99
  albertinii 84
  circinatus 84
  duostratosus 87, 88
  farlowii 89
  hispidans 84
  hispidus 99
  jamaicensis 179
  mikadoi 92
  munzii 93
  splitgerberi 179
  tomentosus 95
  victoriensis 101
Irpex 93
  lacteus 179
Ischnoderma
  resinosum 95

Junghuhnia
  undigera 179

Karoowia 332
Kotlabaea
  deformis 459

Laccaria 305
Lachnea 473
  subg. Lachneolina 473
  subg. Scutellinia 473
  sect. Setosae 473
  sect. Tenues 473
  subsect. Fuscae 473, 477
  subsect. Luteae 473
  amphidoxa 481, 482
  austriaca 440
  cadaverina 477
  coccinea 443
  rubra 477
Lactarius 349, 350, 375, 379, 386
  argillaceifolius 379
  camphoratus 355, 379
  chrysorheus 375, 379
  deceptivus
    var. deceptivus 349, 372, 379
  deliciosus 375, 379
  eburneus
    var. ervinii 349-351, 353, 377, 380
  fragilis 349, 351, 352, 355, 361, 380
    var. fragilis 354, 355
  fuliginellus 349, 368, 369, 372, 380
  fuliginosus 380
  fumosus 380
  gerardii
    var. fagicola 349, 352, 355, 358, 373, 380
    var. gerardii 349, 358, 369, 371, 372, 380
    var. subrubescens 349, 352, 356, 358, 373, 381
  hygrophoroides 381
    var. hygrophoroides 349, 373
  indigo 375, 381
  insulsus 381
  lacunarum 349, 352, 355, 358, 359, 361, 376, 381
  lignyotellus 349, 359-362, 381, 382
  mitissimus 382
  neotropicus 350, 375, 382
  olympianus 382
  pallidus 382
  peckii 382
  piperatus 375, 382
    var. glauscecens 382
  quietus 382
  representaneus 382
  rufus 375, 382
  rugatus 383
  salmonicolor 375, 383
  sanguifluus 383
  scrobiculatus 375, 383
  speciosus 384
  subdulcis 384
  sublacustris 349, 360, 362, 363, 384
  subplinthogalus 349, 360, 364, 365, 377, 384
  subvellereus 367
    var. subdistans 349, 365-368, 375,

    377, 384
  tabidus 384
  texensis 362, 382
  torminosus 375, 384
  uvidus 369, 370
    var. uvidus 349, 374, 376, 384
  vellereus 367, 384
  venezuelanus 375
  veraecrucis 350, 375, 385
  volemus 385
  zonarius 375, 385
Laetiporus
  percicinus 85, 92
Lalaria 315, **318**, 328
  americana **319**, 328
  caerulescens **319**, 329
  carnea **319**, 328
  cerasi **320**, 328
  coccinea **320**, 328
  communis **320**, 328
  confusa **321**, 328
  dearnessii **321**, 328
  deformans **322**, 328
  farlowii **322**, 328
  flavorubra **322**, 328
  johansonii **323**, 328
  letifera **323**, 328
  nana **323**, 328
  polystichi **324**, 329
  populina 318, **325**, 329
  populi-salicis **324**, 329
  pruni-subcordatae **325**, 328
  purpurascens **325**, 328
  robinsoniana **326**, 328
  tosquinetii **326**, 328
  ulmi **327**, 328
  virginica **327**, 328
Lambertella 236
  chromoflava 236
Lamproderma
  arcyrionema 42
  sauteri 51
  scintillans 51
Lamprospora
  lobata 407, 408, 410
Lampteromyces 306
Lanzia 235
  rufescens 234
Laschia
  spatulatus 84
  tonkinensis 410
Lasiobolus 460
Lasiosphaeriopsis
  stereocaulicola 216
Lecanora
  contractula 133, 136
  intricata 136
  muralis 134, 137
  polytropa 136, 137
Lecidea
  nigroleprosa 133, 136
Lenzites
  betulina 179
Leocarpus
  fragilis 52
  vernicosus 52
Lepidoderma
  chailletii 52
Lepiota
  bresadolae 414
  ianthinosquamosa 407, 410
  phaeosticta 407, 413, 414
  phlyctaenodes 407, 413, 414
  subincarnata 407, 413
Leptoderma
  iridescens 52
Leptoporus
  caseosus 183
Leptosphaerella
  bambusae 207
Leptosphaeria 206, 211, 213
  bambusae 207
  consociata 201, 205-207
  saginata 201, 203, 205
  weddellii 211
Leucinocybe 486
  lactifera 486
Leucocoprinus
  bresadolae 407, 413, 414
Leucoinocybe 486
  lactifera 486
  lenta 486
Leucoscypha
  albo-cincta 451
  rutilans 451
Lewia 260, 262, 265
  eureka 258, 260, 264
Licea
  belmontiana 52
  biforis 52
  castanea 52
  denudescens 52
  kleistobolus 52
  iridis 52
  marginata 52
  minima 52
  nannengae 52
  parasitica 52
  pedicellata 53
  perexigua 53
  pusilla 53
  testudinacea 53
  variabilis 53

Lindavia 151
Lindbladia
  tubulina 53
Loweporus
  fuscoalbus 89
  roseoalbus 95
Lycogala
  epidendrum 53
  exiguum 53
  flavofuscum 53
  miniatum 53
Lycoperdon 223
  turneri 221, 223-226
  zeae 274

Macbrideola
  cornea 53
  decapillata 53
  macrospora 54
  oblonga 54
  scintillans 54
  synsporos 54
Macroscyphus
  coccineus 443
Masonhalea 343
Megasporoporia
  setulosa 179
Melanelia 343
Menispora 13, 14
  apicalis 12
  fairmanae 12
  glauco-nigra 12
Metatrichia
  vesparium 54
Microdochium 205-207
Microglaena 311
  areolata 311
Microporellus 85, 91, 102
  chocolatus 83, **85**, 86
  clemensiae 98
  inusitatus 83, 90, **91**
  obovatus 89, 92, 179
Microsporum
  canis 156
  gypseum 156
Microstoma 438
  floccosum 452
  protracta 451-453
Mirandina
  breviphora 21, 22, 24
  corticola 21, 22, 24
Mixia 315
Mixtura 201, **203**, 205
  saginata 201, **203**, 204
Molliardiomyces 417, 429, 433, 435
  coccinea 429, 430, 435, 436, 440
  dudleyi 417, **432**, 433, 446
  eucoccinea 417, 433, **434**, 443
  occidentalis 434, 448, 450
Monographella 206
  consociata 201, **205**-207
Mucilago
  crustacea 51
    var. crustacea 54
    var. solida 54
  spongiosa 54
Mycena 279, 280, 305, 306, 486
  acicula 279, 281, 285, 286, 289-291, 304, 305
  alcalina 279, 281, 285, 286, 292
  amicta 279, 281, 283, 286, 292, 304
  cinerella 279, 281, 284, 286, 293
  epipterygia 279, 281, 284, 286, 293, 305
  galericulata 279, 281, 283, 285, 287, 293-295, 305
  galopus 279, 281, 285, 287, 296, 304-306
  haematopus 279, 281, 285, 287, 296, 306
  maculata 279, 281, 282, 287, 297, 304
  metata 279, 281, 285, 287, 298
  polygramma 279, 281, 284, 287, 299
  pura 279-281, 284, 288, 299, 306
  rorida 279, 281, 284, 288, 299, 304
  rosea 279, 280, 282, 284, 288, 300, 304, 306
  rosella 279, 282, 288, 300, 304, 305
  rubromarginata 279, 282, 283, 288, 300, 301, 304
  sanguinolenta 279, 282, 285, 289, 301, 305
  stipata 286
  stylobates 279, 282, 283, 289, 301, 302, 305
  viridimarginata 279, 282, 283, 289, 303
  vulgaris 279, 282, 283, 289, 303
  zephirus 279, 282-284, 289, 303
Mycosphaerella 205
Myelochroa 340
  immiscens 340
Myrioconium 122
Myxocephala 151
  albida 151

Namakwa 333
Nanoscypha 438
  tetraspora 454
Navisporus
  floccosus 92
  sulcatus 179
Neocallimastix

  frontalis 397
  patriciarum 397
Neofuscelia 343
Neovossia 268
  japonica 267, **268**-270
  pulcherrima 267, **272**
Nephromopsis 332
Nigrofomes
  melanoporus 92
Nitschkea
  bambusarum 213, 214

Ochrolechia
  parella 137
Oligonema
  fulvum 54
Oligoporus
  floriformis 102
  guttulatus 89
  tephroleucus 92, 99
Ombrophila
  conformata 233
  ramella 234
  umbonata
    f. violascens 233
Omphaliaster 486, 488
Omphalotus 306
  olearius 306
Onnia 98
Ophionectria
  erinacea 217, 218
Ophiostoma 109
  minus 103, 106, 107, 109-113
  nigrocarpum 103, 106, 110-114
Orpinomyces 397
  bovis 397, 400, 402
Outhovia 151

Pachykytospora
  alabamae 179
Pandora 230
  gloeospora 227-231
Panellus 306
Paradiacheopsis
  cribata 54
  fimbriata 54
  rigida 54
  solitaria 54
Paraparmelia 339
Paratrichophaea 481
  albescens 481
Parencoelia 117
  andina 117
  kalmiae **117**, 118
Parmelaria 338, 339
Parmelia 331, 336, 337
Parmelina 340
  endoleuca 340
Parmelinella 342
Parmeliopsis 335, 338, 341
  hyperopta 338
  radiculata 341
  swinscowii 341
Parmotrema 334, 335, 339, 340, 342
  dominicanum 335
Parmotremopsis 342
Patella 473
  stercorea 473, 482
Perenniporia 91, 99
  clelandii 99
  detrita 92, 101
  medulla-panis 91, 179
  micropora 93
  neofulva 83, **93**, 94
  ochroleuca 91, 102
  semistipitata 98
  stipitata 91
  subcretacea 83, 96, **99**
Perichaena
  chrysosperma 54
  corticalis 54
  depressa 55
  minor 55
  pedata 55
  vermicularis 55
Pezicula
  kalmiae 117
Peziza 417, 446, 454
  subg. Rhizopodella 437
  subg. Sarcoscypha 437, 439
  subg. Scutellinia 473
  subg. Scypharia 439
  sect. Sarcoscyphae 439
  ser. Lachnea 437, 473
  'tribe' Sarcoscyphae 437-439
  'tribe' Sarcoscyphi 439
  (rank?) Sarcoscypha 437
  (rank?) Sarcoscyphae 437
  (rank?) Scypharia 439
  alphitodes 451
  ascoboloides 480
  ciliata 474, 481, 482
  coccinea 437-439, 443, 446
  colensoi 452
  concentrica 442
  conformata 233, 234
  coprinaria 477
  corium 452
  cruciata 452
  crucipila 481
  dalmeniensis 481, 483
  dudleyi 418, 436, 446
  eclecta 481

[Peziza] epidendra 440
  floccosa 452
  glumarum 481
  granulata 474
  hesperidea 448
  hyalochaeta 482
  imperialis 452
  kalmiae 117
  lobata 408
  melastoma 437, 453
  occidentalis 437, 448, 450
  oligotricha 475, 483
  pulcherrima 453
  pusio 448, 453
  radiculata 453
  raripila 476
  scubalonta 469, 482
  sejournei 236
  stercorea 473, 476, 483
    var. gemella 483
  striispora 454
  subhirsuta 483
    var. hilaris 483
    (rank?) hilaris 483
  theleboloides 474
  umbrorum 483
  vinacea 468, 470, 483
  vitellina 475, 483
    subsp. sabulosa 483
Pezoloma 122
Phaeosphaeria 205, 207, 208
  associata 206-207
  bambusae 207, 208
  oryzae 205, 208
Phallogaster 6
  saccatus 6, 8
Phellinus 98, 99
  apiahynus 173, 179
  bambusarum 173, 179
  discipes 99
  garuhapensis 173, 179
  gilvus 91, 95, 101, 179
  kanehirae 83, 96, **98**
  merrillii 179
  pectinatus 95, 99, 179
  punctatus 179
  robustus 179
  sancti-georgii 179
  senex 91, 101
  setulosus 93
  torulosus 92
  tropicalis 179
  umbrinellus 179
Phialocephala 151
Phialea
  violascens 233, 234
Phillipsia 427, 429
  carminea 451
  lutea 427
  tetraspora 454
Phlebia 91
Phyllachora 117, 216, 217
  kalmiae 117-119
  phyllostachydis 217
Phylliscum
  demangeonii 133, 136
Phylloporia
  bibulosa 85
  chrysita 95, 97, 180
Phyllosticta 207, 208
Physarum
  aeneum 55
  alpinum 55
  auriscalpium 55, 56
  bethelii 55
  bitectum 55
  bivalve 55
  bogoriense 55
  brunneolum 55
  cinereum 55
  compressum 56
  conglomeratum 56
  contextum 56
  crateriforme 56
  decipiens 56
  diderma 56
  didermoides 56
  globuliferum 56
  leucophaeum 56
  leucopus 56
  limonium 56
  listeri 56
  lividum 56, 58
  luteolum 56
  melleum 57
  mortonii 57, 58
  mutabile 57
  newtonii 57
  notabile 57
  nudum 57
  nutans 57
    var. leucophaeum 56
  oblatum 57
  ovisporum 41, 57
  perfectum 57
  pezizoideum
    var. microsporum 57
    var. pezizoideum 57
  pulcherripes 57
  pusillum 57
  robustum 58
  roseum 58
  rubiginosum 58

  serpula 58
  sinuosum 55
  spectabile 56, 58
  spinisporum 58
  straminipes 58
  sulphureum 57, 58
  variabile 58
  vernum 58
  virescens 58
  viride 58
  xanthinum 58
Physcia
  caesia 137
Piloderma 304
  croceum 144
Piptoporus 88
  portentosus 84
  soloniensis 84, 92, 97
Piromyces
  communis 397
Platismatia 337, 338
Plectania 417, 437, 438, 453
  coccinea 438, 443, 453
  hiemalis 451, 452, 453
  melastoma 437, 438, 453
  occidentalis 448
Pleospora 265
Pleurophragmium
  parvisporum 24
Pleurosticta 343
Pleurotus 78, 280, 304
Podoconis
  aturbinata 15
Podonectria
  bambusicola 211, 218
Podospora 30
Polycystis
  lolii 275
Polyporus 78, 83-85, 92, 101
  acervatus 84
  aduncus 84
  albertinii 84
  albo-fuscus 84
  albojavensis 84
  albospongia 84
  amesii 84
  angolensis 84
  arcularius 101, 180
  arcularioides 180
  arensobasus 84
  areosus 84
  armadillus 84
  atrohispidus 84
  aureofulvus 84
  aureus 84
  ballouii 85
  bathei 85
  beardsleii 85
  bibulosus 85
  biogilvus 85
  brockesii 85
  brunneo-maculatus 85
  burkillii 85
  cantharellus 85
  capensis 85
  chocolatus 85
  ciliatus 97
  circinatus 98
  conchatus 85
  conicus 88
  conjunctus 88
  cornucopiae 88
  costatus 88
  cretaceus 88
  cystidioides 88
  deceptivus 88
  dictyopus 85, 92, 95
  dispansus 88
  dorsalis 88
  dubiocochlear 88
  dubiopansus 88
  duostratosus 88
  duroporus 89
  euzonatus 89
  farinosus 89
  farlowii 89
  fijii 89
  fumoso-olivaceus 89
  fuscatus 89
  fuscellus 89
  fusco-dresdensis 89
  fuscolineatus 92
  fusco-mutans 89
  gilvo-rigidus 89
  globocephalus 89
  gossweilerii 89
  grammocephalus 84, 95
  grantii 89
  granulatus 89
  greenii 89
  griseo-durus 89
  guhae 89
  guianensis 180
  haedinus 91
  henningsii 91
  hiascens 91
  hookeri 91
  imporcatus 91
  infulgens 91
  inopinus 91
  intactilis 91
  inusitatus 91
  iowensis 91

[Polyporus] itoi 91
  junctus 91
  juxtarugosus 92
  kanehirae 98
  krakatani 92
  labis 92
  lateritius 92
  leprieurii 180
  maculatissimus 92
  madagascarensis 92
  magnoporus 92
  magnovarius 92
  malnominus 92
  manilaensis 92
  marucuccianus 92
  medullae 92
  melanoporus 92
  mesotalpae 92
  metallicus 92
  mikadoi 92
  mikawai 92
  minuto-durus 92
  mollicarnosus 92
  molliculus 92
  mollitextus 93
  moluccensis 83, **84**
  multilobatus 93
  multiplex 93
  multisetosus 93
  munzii 93
  murrillii 93
  neofulvus 93
  niger 93
  nigrocrustosus 95
  nigrolucidus 95
  nigroporus 95
  nigro-rugosus 95
  nongravis 95
  obniger 95
  orientalis 95
  oroniger 95
  pallido-sporus 95
  papillatus 95
  peakensis 95
  pectunculus 95
  pelles 95
  perturbatus 95
  perversus 95
  poncei 95
  profissilis 95
  propinquus 95
  proprius 95
  pseudofruticum 95
  pseudogilvus 95
  pubertatis 95
  pulcherrimus 183
  puttemansii 173, 180
  radula 97
  retro-ater 97
  rickianus 89
  rosea-brunnea 97
  rosettus 97
  ruforugosus 97
  rugatus 97
  rugiceps 97
  rugosissimus 97
  rugoso-sporus 97
  rusticus 97
  saitoi 97
  salebrosus 97
  salmonicolor 97
  sambuceus 97
  sandakanii 97
  scaurus 97, 98
  semibilanti 98
  semistipitatus 98
  sendaiensis 98
  sepia 98
  simulans 98
  sinensis 98
  smaragdinus 99
  spatulatus 84
  squamosus 180
  strigoso-albus 99
  suaderis 99
  subcretaceus 99
  subhispidus 99
  subradiatus 99
  superniger 99
  tokyoensis 99
  torrendii 99
  tricholoma 180
  trulliformis 99
  turboformis 99
  udus 88, 91, 92
  unilaterus 101
  unitus 101
  ursinulus 101
  vanderystii 101
  vandykeii 101
  varius 92
  velutinosus 101
  versiporus 101
  vicinus 101
  victoriensis 101
  wilsonianus 102
  yasudai 102
  yoshinagai 102
  zambesianus 102
  zebra 102
  zonatulus 102
  zonifer 102
Polystictus 83, 101

  vicinus 101
Porphyrellus 187, 192
Porpidia
  flavocaerulescens 134
  pseudomelinodes 134, 136
Postia
  subcaesia 180
Protomyces 315
Protomycopsis 315
Protoparmelia
  badia 134
Prototrichia
  metallica 58
Pseudevernia 332
Pseudociboria 236
  umbrina 233, 235, 236
Pseudofavolus
  cucullatus 180
Pseudoparmelia 339
Psiloparmelia 334
Pterospora
  nigripes 407, 413
Pterulicium
  xylogenum 409, 410
Punctelia 337
Puttemansia 209
  miakei 201, **209**-211, 218
  rickiana 209
  stromatica 209
Pycnopeziza 236, 237
  pachyderma 233, 236, 237
  quisquiliaris 236, 237
  sympodialis 233, 238
Pycnoporus
  sanguineus 180
Pyrenophora 265
Pyrrhoderma 98
  scaura 83, 96, **97**

Raffaelea 103
Ramaria
  capucina 407, 409, 410
Relicina 334
Relicinopsis 335
Reticularia
  jurana 50
  lycoperdon 50
  olivacea 50
Rhizocarpon
  disporum 137
  geminatum 133, 137
  geographicum 137
  lavatum 133, 137
Rhizopodella 437
Rhizopogon 304
Rhodocybe 486
Rhodotorula 316
Rickenella
  fibula 279, 280, 282, 285, 289, 303, 304
Rigidoporus
  fuscolineatus 89
  laetus 84
  lineatus 180
  microporus 92
  patelarius 180
  sanguinolentus 179
  umbonatipes 173, 180
Rosellinia 216
  crustacea 201, 215
Ruminomyces 398
  elegans 397, **398**-401, 403
Rutstroemia 234
  conformata 233, 234, 237
  nervisequa 233

Sarcinella 275
Sarcoscypha 417, 418, 420-422, 424, 425, 427, 429, 430, 436-441, 453, 454
  (rank?) Macropodia 437
  (rank?) Plectania 437
  albovillosa 451
  alphitodes 451
  alpina 451
  austriaca 417-419, 422, 424, 427-431, 435, 436, 438, 440, 441, 447
  carminea 451
  coccinea 417-419, 422, 424, 425, 427-431, 434-440, 443, 444, 446
    var. jurana 419
  colensoi 452
  concatenata 452
  corium 452
  cruciata 452
  dawsonensis 452
  dudleyi 417-419, 421-424, 426-432, 435, 436, 438, 440, 446, 447
  floccosa 437, 452
  hiemalis 453
  imperialis 452
  jurana 422, 436, 438
  macaronesica 436, 438
  melastoma 437, 453
  occidentalis 417, 418, 422, 423, 425, 427-431, 434-437, 440, 448, 449, 453
  pusio 448, 453
  racovitzae 453
  radiculata 453
  rhenana 453
  roseotincta 454
  striispora 454

[Sarcoscypha] tetraspora 454
Sarcoxylon
  deightonii 80
Schizopora
  flavipora 95, 181
  paradoxa 181
Scleroderma 304
Sclerotinia
  nervisequa 233, 234
  umbonata
    var. alni 233, 234
Scopula 151
Scopularia 150, 152
  corsicana 151
  scopula 150, 151
  venusta 150
Scutellinia 460, 477, 478, 480
  sect. Minutae 460, 478, 480
  sect. Pseudocheilymeniae 460, 478, 480
  alleghenensis 480
  crucipila 481
  umbrorum 483
Scutellispora
  biornata 73
  pellucida 73, 74, 75
Scypharia 439
Sebacina
  dendroidea 79
Sepultaria
  pediseta 475
Sorosporium
  ehrenbergii 267, 270
  ellisii 271
    var. occidentalis 270
    var. provinciale 267, 271
  filiferum 270
  lolii 267, 275
  montiae 276
  provinciale 271
Sowerbyella 452
  imperialis 452
  radiculata 453
  rhenana 437, 453
Sphacelotheca 272
  cheoana 267, 272, 273
  kusanoana 273
  macrochloae 273
  occidentalis 267, 270
  sorghi 275
  spermophora 273
Sphaeria
  clivulosa 211
  phaselina 211
  stegophora 211
  weddellii 201, 211-213
Spongipellis 88, 183
  caseosus 173, 181, 182, 184
  cretaceus 83, **88**
  delectans 95
  spumeus 101
Sporidesmium 15
  aturbinatum 15, 16
  brachypus 18
  calyptratum 15, **16**
  filirostratum 15, **16**
  fusiforme 19
  longirostratum 18
  longisporum 15, 16, **18**
  pedunculatum 15, 16, 19
  spegazzinii 15, 16, **18**
Sporisorium 272
  cruentum 275
  ehrenbergii 267, **270**
  formosanum 274
  occidentale 267, **270**
  provinciale 267, **271**
  sorghi 267, 275
Sporothrix 103, 106, 113
Spumaria
  alba 54
Stemonitis
  axifera 58
  emotoi 59
  fasciculata 58, 59
  ferruginea 58
  flavogenita 59
  fusca 59
  herbatica 59
  hyperopta 60
  leucopodia 45
  microsperma 59
  nigrescens 59
  ovata 43
  pallida 59
  smithii 59
  splendens
    var. flaccida 60
    var. splendens 59
    var. webberi 59
  typhina 60
  uvifera 59
  virginiensis 59
Stemonitopsis
  amoena 43, 60
  hyperopta 43, 60
  typhina 43, 60
Stemphylium 275
Stereocaulon
  alpinum 138
  arenarium 133, 138
  symphycheilum 133, 138
  vesuvianum 138
Strobilomyces 305

Subulispora
  argentina 22
Suillus 304
  luteus 142, 144
Symphytocarpus
  amaurochaetoides 60
  flaccidus 60
  impexus 60

Taphridium 315
Taphrina 315, 316
  americana 319
  betulina 316
  caerulescens 316, 319, 320
  carnea 320
  cerasi 320
  communis 321
  confusa 321
  dearnessii 321
  deformans 322
  farlowii 322
  flavorubra 323
  johansonii 323
  lapponica 316
  letifera 323
  nana 317, 324
  polystichi 317, 324
  populina 325
  populi-salicis 324
  pruni-subcordatae 325
  purpurascens 326
  robinsoniana 326
  tosquinetii 326
  turgida 316
  ulmi 327
  virginica 327
Tetracrium 209
Thecaphora 275
  ammophilae 275
  andropogonis 275
  berkeleyana 275
  dactylidis 275
  herteriana 275
  inquinans 267, 275
  westendorpii 275
Thelenella 311
Thuemenella 77, 80
  cubispora 77, 80
  javanica 80
Tilletia 268
  alopecuri 268
  controversa 268
  corona 268
  maclagani 272
  pulcherrima 267, 272
  rotundata 272
  youngii 268
Tilmadoche
  nutans 57
Togninia 213, 214
  inconspicua 201, **213**, 214
  minima 213
Tolyposporium 276
  ehrenbergii 270
  filiferum 267, 270
  montiae 267, 276
Trametes 83, 97
  cingulata 89
  ectypus 89
  elegans 184
  radiatorugosa 92
  varians 95
  versicolor 184
  villosus 184
Trappea 1, **2**, 3
  darkeri 1, **3**, 4, 6, 8
  phillipsii 1, 3, **7**, 8
Trematosphaerella
  bambusae 207
Trematosphaeria 205, 216
  crustacea 201, **215**, 216
  perrumpens 216
Tremolecia
  atrata 134, 136
Trichaptum
  biforme 184
  sector 184
Tricharina 481, 482
  bisetosa 481
  flava 474, **481**
  ochroleuca 482
Trichia
  affinis 60
  botrytis 60
  chrysosperma 61
  clavata 51
  contorta
    var. attenuata 60
    var. contorta 60
    var. iowensis 60
    var. karstenii 61
  decipiens
    var. decipiens 61
    var. olivacea 61
  favoginea 61
  flavicoma 61
  floriformis 61
  lutescens 61
  munda 61
  ovata 61
  persimilis 61
  scabra 61
  subfusca 61

[Trichia] varia 61
Tricholoma 486, 488, 490
  sect. Iorigida 488
  goniospermum 492
  nodulosporum 488
  tetragonosporum 492
Tricholosporum 485-488, 490, 491
  atroviolaceum 485, 492
  goniospermum 485, 488, 492
  longicystidiosum 485, **490**-493
  porphyrophyllum 485, 488, 492
  pseudosordidum 485, 488, 492
  subporphyrophyllum 485-488, 491-493
Trichonectria
  bambusicola 211, 217, 218
Trichopeziza
  kalmiae 117
Trichophyton
  interdigitale 156
  mentagrophytes 156
  rubrum 156
Tubifera
  ferruginosa 62
  papillata 62
Tuburcinia 271
  asphodeli 267, 271
  clintoniae 267, 271
  orobanches 271
  paridis 271
  primulae 271
  primulicola 271
  trientalis 271
Tuckermannopsis 336
Tylopilus 187, 190, 192, 194, 195, 197
  subg. Porphyrellus 192
  subg. Tylopilus 192
  appalachiensis 187-190, 194, 195
  cellulosus 187, 190-192
  felleus 190
  ferrugineus 199
  minor 187, 192-197
  peralbidus 195
    var. peralbidus 195
    var. rhodoconius 187, 194-196
  tabacinus 199
    var. amarus 187
    var. dubius 187, 197-199
    var. tabacinus 199
    var. typicus 199
Tyromyces 183
  campylus 97, 102
  fissilis 89
  fumidiceps 99
  leucomallus 184
  pelliculosus 84, 95, 99

Uleomyces
  tapirae 201, 216, 217
Urceolaria
  areolata 311
Uredinophila 218
  erinacea 209, 211, 217, 218
Uredo
  subg. Ustilago 274
  digitariae 274
  maydis 274
  zeae 274
Urocystis 271, 275
  asphodeli 267, **271**
  clintoniae 267, **271**
  galanthi 267, 275
  herteriana 275
Ustilago 274
  andropogonis-finitimi 267, 275
  cynodontis 274
  digitariae 274
    f. panici-repentis 267, 274
  formosana 274
  halophila 273, 274
  hypodytes 267, 273, 274
  jacksonii 273, 274
  kusanoana 273
  macrochloae 267, 273, 274
  maydis 267, 274, 276
  minima 273, 274
  orientalis 267, 272, 273
  reiliana
    f. sorghi cernui 275
  sparti 273, 274
  spermophora 267, 272-273
    var. orientalis 273
  stipae-barbatae 273
  williamsii 273, 274
  zeae 274

Velutarina 237
Veronaea 167
  botryosa 170
  caricis 170
  carlinae 170
  constricta **167**, 170
  coprophila 170
  gorakhpurensis 170
  smilacis 170
  tectonae 170
  verrucosa 170
Verticillium
  fungicola 227
Volkartia 315

Wettsteinina 205

Xanthoconium 197
Xanthocrous
  duporti 177
Xanthomaculina 333
  convoluta 333
Xanthoparmelia 334-336
Xanthoria
  candelaria 137
  elegans 134, 137
  parietina 137
Xeromphalina
  brunneola 305
  tenuipes 409

Zoophthora
  gloeospora 228

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[CONTENTS continued from inside front cover]

NOTICE: Forthcoming major editorial changes 500

Author INDEX 501
Reviewers 504
INDEX to Fungous and Lichen Taxa 505
Errata 524
Publication date, MYCOTAXON Volume 37 524

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